Urban space and structures

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I. *The grid as generator*[†]

LESLIE MARTIN

1

The activity called city planning, or urban design, or just planning, is being sharply questioned. It is not simply that these questions come from those who are opposed to any kind of planning. Nor is it because so many of the physical effects of planning seem to be piecemeal. For example roads can be proposed without any real consideration of their effect on environment; the answer to such proposals could be that they are just not planning at all. But it is *not* just this type of criticism that is raised. The attack is more fundamental: what is being questioned is the adequacy of the assumptions on which planning doctrine is based.

What are those assumptions? To put this in the most general terms, they resolve themselves into two powerful lines of thought. The first, which stems from the work of the Viennese writer Camillo Sitte, whose book *City Planning according to Artistic Principles* was published in 1889, can be called the doctrine of the visually ordered city. To Sitte the total city plan is the inspired and the all encompassing work of art. But Sitte went further: civic art must be an expression of the life of the community, and finally 'works of art cannot be created by committee but only by a single individual' (Collins 1965).[‡] The planner then is the inspired artist expressing in the total city plan the ambitions of a society. There are indeed many who, though not prepared to accept this total – it would not be inaccurate to say this totalitarian – role of the planner, have nevertheless been profoundly influenced by Sitte's doctrine of the visually ordered city. The doctrine has left its mark on the images that are used to illustrate high density development of cities. It is to be seen equally in the layout and arrangement of Garden City development. The predominance of the visual image is evident in some proposals that work for the preservation of the past: it is again evident in the work of those that would carry us on, by an imagery of mechanisms, into the future. It remains central in the proposals of others who feel that, although the city as a total work of art is unlikely to be achieved, the changing aspect of its streets and squares may be ordered visually into a succession of pictures. The second line of doctrine is severely practical. It can be called the doctrine of the statistically ordered city. We know it well. It is the basis of those planning surveys in which uses are quantified, sorted out and zoned into particular areas; population densities are assessed and growth and change predicted. It is the raw material of the outline analyses and the town maps of the 1947 Act.

† Some parts of 'The grid as generator' were used in the Gropius Lecture at Harvard University in June 1966. The argument was developed later into the theme delivered at the University of Hull under the title, 'The Framework of Planning', as the inaugural lecture by Leslie Martin as Visiting Ferens Professor of Fine Art. It is presented here in essentially that form.

‡ See also a review of both Sitte 1889 and Collins 1965 in L. March (1966).

Now it is precisely these two aspects of planning (the first concerned with visual images and the second with procedure, and sometimes of course used in combination by planners), that were so sharply attacked by Mrs Jane Jacobs in her book *The Death and Life of Great American Cities* (1961). For Mrs Jacobs, both 'the art of city planning and its companion, the pseudo-science of city planning, have not yet embarked on the effort to probe the real world of living'. For her a city can never be the total work of art, nor can there ever be the statistically organised city. Indeed, to Mrs Jacobs, the planning of any kind of order seems to be inconsistent with the organic development of cities which she sees as a direct outcome of the activities of living. Planning is a restrictive imposition: the areas of cities 'in which people have lived are a natural growth...as natural as the beds of oysters'. Planning, she says, is essentially artificial.

It is of course just this opposition between 'organic' growth and the artificial nature of plans, between living and the preconceived system within which it might operate, that has been stressed so much in recent criticism. Christopher Alexander in a distinguished essay 'A city is not a tree' puts the point directly when he says:

> I want to call those cities that have arisen spontaneously over many many years 'natural cities'. And I shall call those cities or parts of cities that have been deliberately created by planners 'artificial cities'. Siena, Liverpool, Kyoto, Manhattan, are examples of *natural cities*. Levittown, Chandigarh and the British New Towns are examples of *artificial cities*. It is more and more widely recognised today that there is some essential ingredient missing in the artificial cities (Alexander 1966).

Let us consider this. First of all would it be true to say that all old towns are a kind of spontaneous growth and that there have never been 'artificial' or consciously planned towns in history? Leaving on one side ancient history, what about the four hundred extremely well documented cases of new towns (deliberately planted towns) that Professor Beresford

has collected for the Middle Ages in England, Wales and Gascony alone? (Beresford 1967.) What about the mediaeval towns such as those built in Gascony between 1250 and 1318 on a systematic gridiron plan? All these towns were highly artificial in Alexander's sense. The planted town, as Professor Beresford observes, 'is not a prisoner of an architectural past: it has no past'. In it the best use of land meant an orderly use, hence the grid plan. In siting it and building it estimates had to be made about its future, about its trade, its population, and the size and number of its building plots. This contributes a highly artificial procedure.

But it is of course by no means uncommon. Indeed it is the method by which towns have been created in any rapidly developing or colonial situation. A recent book by John Reps, *The Making of Urban America* (1965) is a massive compendium of the planting of new towns throughout America, practically all of them based on highly artificial gridiron plans. He points out that there is a sense in which not merely cities but the whole of Western America is developed within an artificial frame: 'the giant gridiron imposed upon the natural landscape by...the land ordinance of 1785'.

The coloniser knows that the natural wilderness has to be transformed: areas must be reserved for agriculture as well as plots for building. The man-made landscape is a single entity: cities and their dependant agricultural areas are not separate elements. All these things are matters of measure and quantity. They are interrelated between themselves and numbers of people. The process demands a quality of abstract thought: a geometry and a relationship of numbers worked out in advance and irrespective of site. The 20-mile square plan for the proposed colony of Azilia, the plans of Savannah and Georgetown, are typical examples of this kind of thought. William Penn's plan for Philadelphia, the plans of such towns as Louisville, Cincinnati, Cleveland, New York City itself, Chicago and San Francisco, are all built on the basis of a preconceived frame.

In the case of the mediaeval towns described by Beresford, whilst some failed, a high proportion succeeded in their time. In a large number of American cities, the artificial grid originally laid down remains the working frame within which vigorous modern cities have developed. It is quite clear then that an artificial frame of some kind does not exclude the possibility of an organic development. The artificial grid of streets that was laid down throughout Manhattan in 1811 has not prevented the growth of those overlapping patterns of human activity which caused Alexander to describe New York as an organic city. Life and living have filled it out but the grid is there.

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In the case of the mediaeval towns described by Beresford, whilst some failed, a high proportion succeeded in their time. In a large number of American cities, the artificial grid originally laid down remains the working frame within which vigorous modern cities have developed. It is quite clear then that an artificial frame of some kind does not exclude the possibility of an organic development. The artificial grid of streets that was laid down throughout Manhattan in 1811 has not prevented the growth of those overlapping patterns of human activity which caused Alexander to describe New York as an organic city. Life and living have filled it out but the grid is there.

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What he is criticising in the extended content of his essay, is the notion that the activities of living can be parcelled out into separate entities and can be fixed for ever by a plan. The assumption is common in much post-war planning. Consider an example. Housing is thought of in terms of density: 75, 100, 150 people per acre. That will occupy an area of land. Housing requires schools and they need open space: that will occupy another specific area. These areas in turn may be thought to justify another need: an area for recreation. That is one kind of thought about planning. But alternatively an effort may be made to see the needs of a community as a whole. It may be discovered that the way housing is arranged on the ground may provide so much free space that the needs of schools or recreation will overlap and may even be contained within it (Martin 1968).

In the first instance the uses are regarded as self-contained entities: Alexander equates this kind of thinking with an organisation like that demonstrated by a mathematical tree. In the second instance the patterns of use overlap: the organisation in this case is much closer to a far more complex mathematical structure: the semi-lattice. The illustration of the separate consideration of housing, schools and open space is elementary. But it is Alexander's argument that whole towns may be planned on this basis. And it is this attempt to deal with highly complex and overlapping patterns of use, of contacts and of communications in a way which prevents this overlap from happening that Alexander deplores. Hence the title of his paper: 'A city is not a tree'. In this sense of course he is correct. But the argument can be put in a different way. It can be argued that the notion (implied by Mrs Jacobs) that elaborate patterns of living can never develop within a preconceived and artificial framework is entirely false. This can be developed by saying that an 'organic' growth, without the structuring element of some kind of framework, is chaos. And finally that it is only through the understanding of that structuring framework that we can open up the range of choices and opportunities for future development.

The argument is this. Many towns of course grew up organically by accretion. Others, and they are numerous and just as flourishing, were established with a preconceived framework as a basis. Both are built up ultimately from a range of fairly simple formal situations: the grid of streets, the plots which this pattern creates and the building arrangements that are placed on these. The whole pattern of social behaviour has been elaborated within a limited number of arrangements of this kind and this is true of the organic as well as the constructed town. Willmott and Young, studying kinship in the East End of London (1957), were able to show that everywhere elaborate patterns of living had been built up. All these elaborations, and a great variety of needs, were met within a general

building pattern of terraces and streets. Change that pattern and you may prevent these relationships from developing or you may open up new choices that were not available in the original building form.

The grid of streets and plots from which a city is composed, is like a net placed or thrown upon the ground. This might be called the framework of urbanisation. That framework remains the controlling factor of the way we build whether it is artificial, regular and preconceived, or organic and distorted by historical accident or accretion. And the way we build may either limit or open up new possibilities in the way in which we choose to live.

The understanding of the way the scale and pattern of this framework, net or grid affects the possible building arrangements on the land within it, is fundamental to any reconsideration of the structure of existing towns. It is equally important in relation to any consideration of the developing metropolitan regions outside existing towns. The pattern of the grid of roads in a town or region is a kind of playboard that sets out the rules of the game. The rules outline the kind of game; but the players should have the opportunity to use to the full their individual skills whilst playing it.

2

How does the framework of a city work? In what way does the grid act as a generator and controlling influence on city form? How can it tolerate growth and change?

The answer to these questions is best given by historical examples, and in order to give the argument some point we can deliberately choose the most artificial framework for a city that exists: the grid as it has been used in the United States, and so well illustrated by Reps (1965).

We can start with the notion that to the coloniser the uncultivated wilderness must be tamed into a single urban–rural relationship. In the plan for the proposed Margravate of Azilia (the forerunner of the colony of Georgia) the ground to be controlled is 20 miles square, or 256,000 acres. Implicit in the subdivisions of this general square is a mile square grid; and out of the basic grid the areas for farmland, the great parks for the propagation of cattle and the individual estates are built up. At the centre is the city proper.

The Margravate was never built, but the concept of the single urban–rural unit and the principle of a grid controlled land sub-division within this remains. In the County map of Savannah, Georgia, made in 1735, a grid of (slightly less than) one mile square sub-divides a rectangle nearly 10 miles long and 6 miles deep. Thirty nine of these squares remain wooded areas: within this primary sub-division, further sub-divisions create farms

of 44 acres and 5-acre garden plots. These are the related grid systems of the city region. On the river front within this main system is the city itself.

Now it is this city grid of Savannah that can be used as a first example of a city grid. A view of Savannah in 1734 illustrated in John Reps' book describes the principle: the plots and streets of the embryo city are being laid out: some buildings are complete. The unit of the Savannah grid is square: it is called a ward and is separated from its neighbours by wide streets. Within each square (or ward) building plots for houses are arranged along two sides, the centre itself is open, and on each side of this open square are sites for shops and public buildings. Savannah grew by the addition of these ward units. In 1733 there were four units: in 1856 no less than twenty-four. The city became a chequer board of square ward units, marked out by the street pattern. But within this again, the plaid is further elaborated. The central open spaces of each ward are connected in one direction by intermediate roads, in the other direction the central areas become a continuous band of open spaces and public buildings. Here is a unit grid with direction and orientation.

The second example of a grid is absolutely neutral. It lays down an extensive and uniform pattern of streets and plots. The whole process can be illustrated in one single large scale example. In 1811 the largest city grid ever to be created was imposed upon a landscape. The unlikely site for this enterprise was an area of land between two geophysical provinces in which a succession of tilts, uplifts and erosions had brought through the younger strata two layers of crystalline rock. These appeared as rocky outcrops under a thin layer of soil and vegetation. Into their depressions sands and gravels had been deposited by glacial action to create swampy areas through which wandered brooks and creeks. Some of these still wander into the basements of the older areas of what is now Manhattan.

In 1613 the original Dutch settlement was limited to the tip of the island. In 1760 there was little expansion beyond this and contemporary illustrations depict to the north a rolling landscape. Taylor's plan of 1796 shows the first modest growth of a city laid out on a gridiron pattern. Surveys in 1785 and 1796 extending up the centre of Manhattan set out the basis for a grid, and in 1811 the special State Commissioners confirmed this in an 8 ft long plan which plotted the numbered street system of Manhattan as far north as 155th Street. The plan showed 12 north–south avenues each 100 ft wide and 155 cross streets each 66 ft wide. The size of the rectangular building plots set out by this grid are generally 600 ft by 200 ft. There were some public open spaces. (Central Park was of course carved out later.) And it is this framework that has served the successive developments of the built form from 1811 to the present day.

The third example of a city grid is of interest because of its dimensional

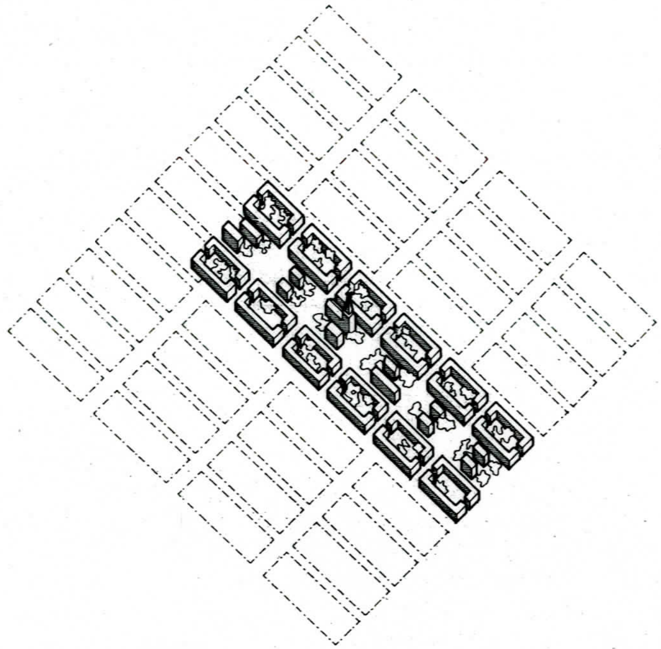


Fig. 1.1. The basic plot layout of Manhattan is shown in the dotted lines. On this, four wards of the Savannah type of development have been superimposed. The example shows the effective way in which this layout opens up broad bands of green space and public buildings running across the developed areas.

links with the land ordinance, suggested by Thomas Jefferson and passed by Congress in 1785. Under that ordinance a huge network of survey lines was thrown across all the land north and west of the Ohio river (Robinson 1916). The base lines and principal meridians of the survey divided the landscape into squares 36 miles each side. These in turn were subdivided into 6-mile squares or townships and further divided into 36 sections each one mile square. The mile squares are then subdivided by acreage: the quarter section 160 acres with further possible subdivisions of 80, 40, 20, 10 or 5 acres. The 5-acre sites lend themselves to further division into rectangular city blocks (not unlike those of Manhattan) and subdivision again into lots or building plots.

In 1832, according to Reps (1965), Chicago was not much more than a few log cabins on a swamp. The railway came in the mid-century and by the seventies and eighties a mile square grid had been extended over a considerable area of the prairie and the city framework had developed

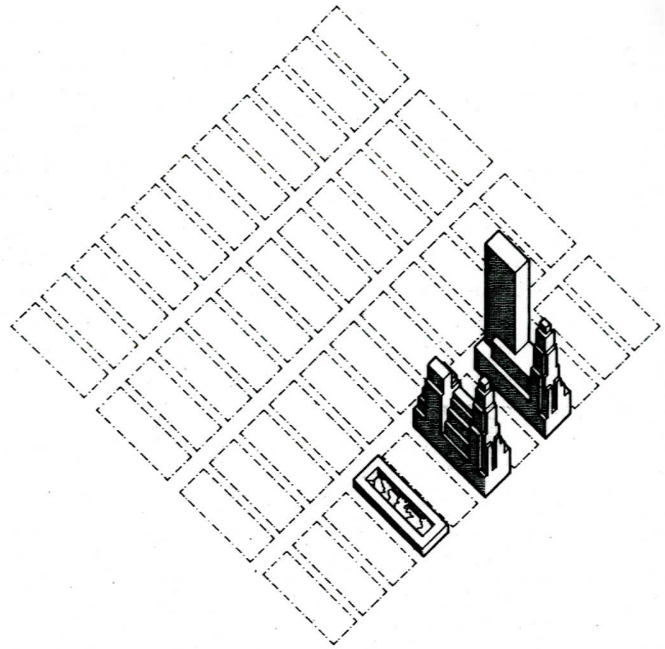


Fig. 1.2. The basic plot layout of Manhattan is shown again in the dotted lines. The building forms show three stages of development including the original 4–6-storey perimeter form with a garden at the centre which was characteristic of the city in the 1850s, and two examples of the more intensive development during the present century.

within this through a plaiting and weaving of the subdivisions that have been described.

Here then are three types of grid, that of Savannah, the gridiron of Manhattan and that of Chicago. Each one is rectangular. Each one has admitted change in the form and style of its building. Each one has admitted growth, by intensification of land use or by extension. Savannah, as it grew, tended to produce a green and dispersed city of open squares (Fig. 1.1). In Manhattan, the small scale subdivision of the grid and the exceptional pressure to increase floor space within this, forced buildings upwards. Chicago spread, continually opening out the pattern of its grid. In each case the influence of the original grid remains: each one offers different possibilities and choices of building and of living.

In order to trace the influence of the grid, we can examine the building arrangement that developed within it in New York. We can identify at once what might be called the streets and the system that is established by

the grid. If we now use the language of the urban geographers, we know that this defines the general plot pattern. The building arrangement develops within this (Conzen 1962).

The stages of this latter process can be traced in the early plans of Manhattan produced in 1850. The grid of roads is already built. Within this general plot pattern the separate building plots are being established. To the north, on the building frontier, there is a line of huts and shacks. Further south more permanent but separate buildings are being built. And in the most developed area further towards the tip of Manhattan the full building arrangement has solidified into connected terraces of four to six-storey houses arranged around the perimeter of the site and enclosing private gardens. Views of Manhattan in the 1850s show a city developed in this way: and this pattern of building arrangement can still be seen in many areas. At this point the building land is replete. A balance is maintained between the plot, the amount of building that it can reasonably support and the street system that serves this.

But as the pressure for floor space increases, the building form changes intensively at certain nodal points (Fig. 1.2). Deeper and higher perimeter buildings first of all submerge the internal garden space. A process of colonisation of the individual building plots begins, so that larger areas of the general plot are covered by higher buildings. In 1916 the first single building to occupy an entire city block rose a sheer 600 ft; its roof space almost exactly equalled the area of its ground plan. It was this building that most clearly illustrated the need for the comprehensive zoning ordinances adopted that year, after arduous study and political compromise, to safeguard daylight in streets and adjoining buildings. But the grid now exerts a powerful influence: the limited size of the grid suggests the notion that increased floor space in an area can only be gained by tall buildings on each separate plot. The notion suggests the form; the regulations shape it into ziggurats and towers. Under the regulations that prevailed until recent years, if all the general building plots in central Manhattan had been fully developed, there would have been one single and universal tall building shape. And, to use an old argument by Raymond Unwin (1912), if the population of those buildings had been let out at a given moment, there would have been no room for them in the streets. The balance between area of plot, area of floor space and area of street has disappeared.

Now these descriptions of the grid, which have been used as a basis for the argument, have exposed the points at which it can be, and has been, extensively attacked for more than a century. A grid of any kind appears to be a rigid imposition on the natural landscape. It is this reaction against the grid that is voiced by Olmstead and Vaux writing in support of their

design for Central Park in 1863: 'The time will come when New York will be built up, when all the grading and the filling will be done and the picturesquely varied rocky formation of the island will have been converted into formations for rows of monotonous straight streets and piles of erect buildings' (Reps 1965).

In their opposition to the grid, the relief from its monotony became a specific aim. Central Park itself is an attempt to imitate nature and to recreate wild scenery within the grid.† The garden suburb with its curving streets is one form of attack on the grid system, and an attempt to replace it. And at the end of the century, the Chicago Fair (1893), Cass Gilbert's schemes in Washington (1900), and the plans for San Francisco (1905) and Chicago (1909) by Burnham are another attempt to transform the urban desert by means of vistas and focal points, into the 'city beautiful'. However, we recognise at once a contrast. The various types of grid that have been described opened up some possible patterns for the structure of a city but left the building form free to develop and change within this. The plans of the garden city designers or those concerned with making the 'city beautiful' are an attempt to impose a form: and that form cannot change.

It is not possible to deny the force behind the criticisms of the grid. It can result in monotony: so can a curvilinear suburbia. It can fail to work: so can the organic city. What has been described is a process. It is now possible to extract some principles. Artificial grids of various kinds have been laid down. The choice of the grid allows different patterns of living to develop and different choices to be elaborated. The grid, unlike the fixed visual image, can accept and respond to growth and change. It can be developed unimaginatively and monotonously or with great freedom. There can be a point at which the original grid fails to respond to new demands (Fig. 1.3). As in Manhattan, it congeals. And it is at this point that we must try to discover from the old framework a new ordering principle that will open up new opportunities for elaboration by use.

It is precisely this that Le Corbusier underlined when he paid his first visit to New York in 1935 and made the comment: 'What about the road?' (Le Corbusier 1939, 1947.) The diagrams by which he illustrates this

† This movement which began with gardens, was less appropriately applied to city layout. In Olmstead's words, 'lines of roads were not to press forwards'. Their curving forms suggest leisure and tranquility. Compare this with the almost contemporary (1859) statements by Cerda in his plan for Barcelona in which there is 'a reciprocal arrangement between that which is contained' (building plot and arrangement) and 'that which contains' (grid and street system). 'Urbanisation is an appendix to universal movement: streets are for movement but they serve areas permanently reserved and isolated from that movement which agitates life' (the environmental area).

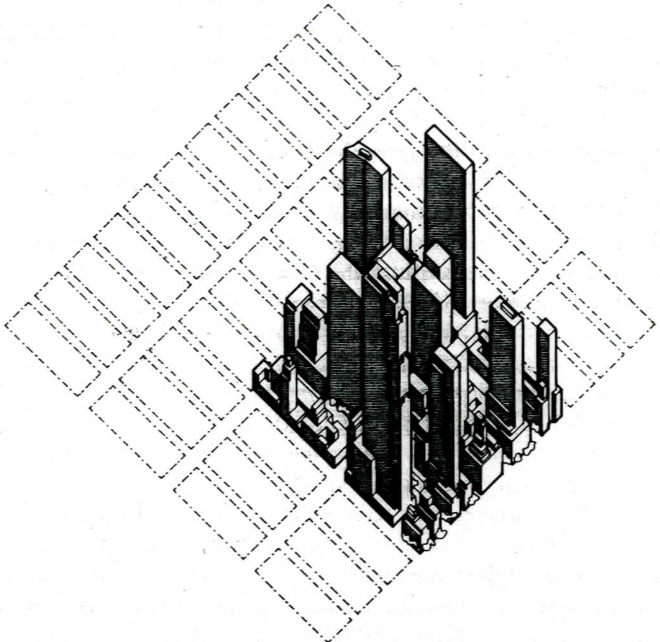


Fig. 1.3. The illustration shows building plot development in its most intensive form.

remark show the regenerative process that is necessary (Fig. 1.4). By increasing the size of the street net in Manhattan, Le Corbusier shows that the grid ceases to restrict. New building arrangements become possible and the balance between plot, building and street can be restored.

In the larger and more open mile square network of Chicago Frank Lloyd Wright had given a similar and vivid illustration of the capacity of the grid to respond to diversity and freedom. In 1913 a competition was held in order to 'awaken interest in methods of dividing land in the interests of a community' (Yeomans 1916). The site was the standard section of the mile square grid. The standard subdivision of the grid, if rigidly applied, could divide it into 32 rectangles each 600 ft long by 250 ft deep. Mr Wright accepts the established gridiron of the city 'as a basis' for subdivision. He accepts the 'characteristic aggregation of buildings... common to every semi-urban area of Chicago'. The same number of people are housed. The business buildings, the factories, the heating plant, the utilities of the area are all there. But to use his words 'they cling naturally to the main arteries of traffic. By thus drawing...all buildings of

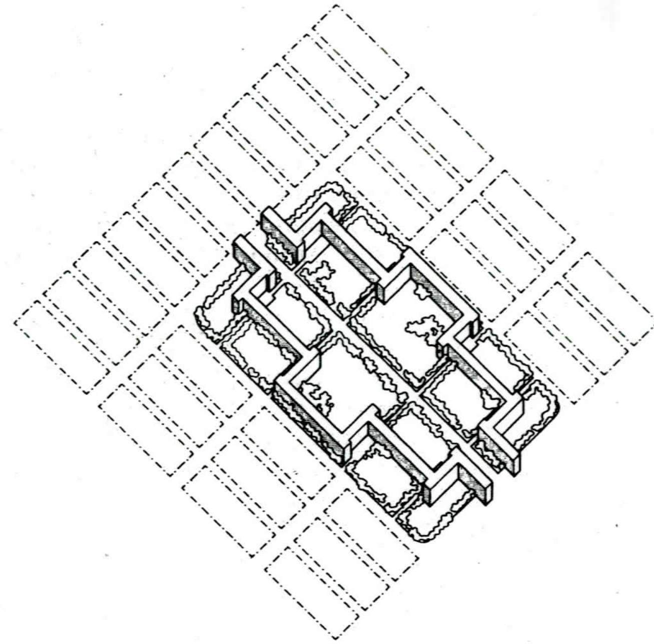


Fig. 1.4. Change in the scale of the grid. Le Corbusier's proposals for dwellings with setbacks (from his proposals for a city for 3 million people) are superimposed on the Manhattan grid and open up new possibilities in the building form.

this nature into the location that they would prefer the great mass of the subdivision is left clear for residence purposes'. Within this area parks (with their exhibition galleries and theatres), tree-lined avenues and stretches of water diversify the layout. The range and choice of housing is wide. It is all natural, relaxed, capable of infinite variation and change as it develops within the framework of the grid. Mr Wright's descriptive text includes these words: 'in skilled hands the various treatments could rise to great beauty'. It is prefaced by a quotation from Carlyle: 'Fool! the ideal is within thyself. Thy condition is the stuff thou shalt shape that same ideal out of.'

3

In the case of these American cities the grid or framework can be regarded as an ordering principle. It sets out the rules of the environmental game. It allows the player the freedom to play with individual skill. The argument can now be extended by saying that the grid, which is so apparent in the

American examples, is no less controlling and no less important in cities nearer home that would normally be called organic: London, Liverpool or Manchester. They too have a network of streets and however much the grid is distorted, it is there. At a certain scale and under certain pressures the grid combined with floor space limits and daylight controls is just as likely to force tall building solutions. And it is just as likely to congeal. It lends itself just as readily to regenerative action. The theoretical understanding of the interaction between the grid and the built form is therefore fundamental in considering either existing towns or the developing metropolitan regions.

The process of understanding this theoretical basis rests in measurement and relationships and it goes back certainly to Ebenezer Howard. Lionel March has recently pointed out a number of interesting things about Howard's book *Tomorrow: a peaceful path to real reform* first published in 1898. It is a book about how people might live in towns and how these might be distributed. But the important thing is that there is no image of what a town might look like. We know the type of housing, the size of plot, the sizes of avenues. We know that shopping, schools and places of work are all within walking distance of the residential areas. On the basis of these measurements we know the size of a town and the size of Howard's cluster of towns which he calls a city Federation. We know the choice that is offered and we know the measurements that relate to these. If we disagree with the choice we can change the measurements. Lionel March (1967) took Howard's open centred city pattern linked by railways and showed that it could be reversed into a linear pattern linked by roads and that such patterns could be tested against the land occupied by our present stock of building and our future needs.

Now that is theory. It contains a body of ideas which are set down in measurable terms. It is open to rational argument. And as we challenge it successfully we develop its power. The results are frequently surprising and sometimes astonishingly simple. Ebenezer Howard's direct successor in this field was Raymond Unwin. The strength of his argument always rests in a simple demonstration of a mathematical fact. In an essay 'Nothing gained by overcrowding' (Unwin 1912), he presents two diagrams of development on ten acres of land. One is typical development of parallel rows of dwellings: the other places dwellings round the perimeter. The second places fewer houses on the land but when all the variables are taken into account (including the savings on road costs) total development costs can be cut. From the point of view of theory, the important aspect of this study is the recognition of related factors: the land available, the built from placed on this, and the roads necessary to serve these. He demonstrated this in a simple diagram.

Unwin began a lecture on tall building by a reference to a controversy that had profoundly moved the theological world of its day, namely, how many angels could stand on a needle point. His method of confounding the urban theologians by whom he was surrounded was to measure out the space required in the streets and sidewalks by the people and cars generated by 5-, 10- and 20-storey buildings on an identical site. The interrelationship of measurable factors is again clearly demonstrated. But one of Unwin's most forceful contributions to theory is his recognition of the fact that 'the area of a circle is increased not in the direct proportion to the distance to be travelled from the centre to the circumference, but in proportion to the square of that distance'. Unwin used this geometrical principle to make a neat point about commuting time: as the population increases round the perimeter of a town, the commuting time is not increased in direct proportion to this.

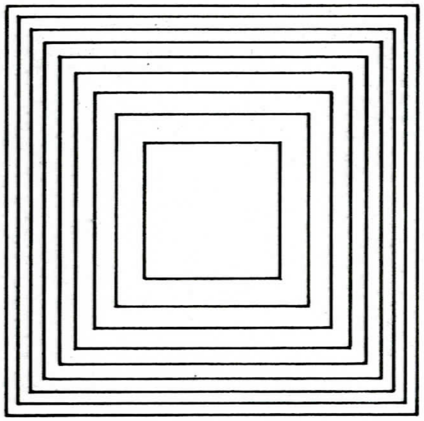


Fig. 1.5

The importance of this geometrical principle is profound. Unwin did not pursue its implications. He was too concerned to make his limited point about low density. But suppose this proposition is subjected to close examination. The principle is demonstrated again in Fresnel's diagram (Fig. 1.5) in which each successive annular ring diminishes in width but has exactly the same area as its predecessor. The outer band in the square form of this diagram has exactly the same area as the central square. And this lies at the root of our understanding of an important principle in relation to the way in which buildings are placed on the land.

Suppose now that the central square and the outer annulus of the Fresnel diagram are considered as two possible ways of placing the same amount

of floor space on the same site area: at once it is clear that the two buildings so arranged would pose totally different questions of access, of how the free space is distributed around them and what natural lighting and view the rooms within them might have. By this process a number of parameters have been defined which need to be considered in any theoretical attempt to understand land use by buildings.

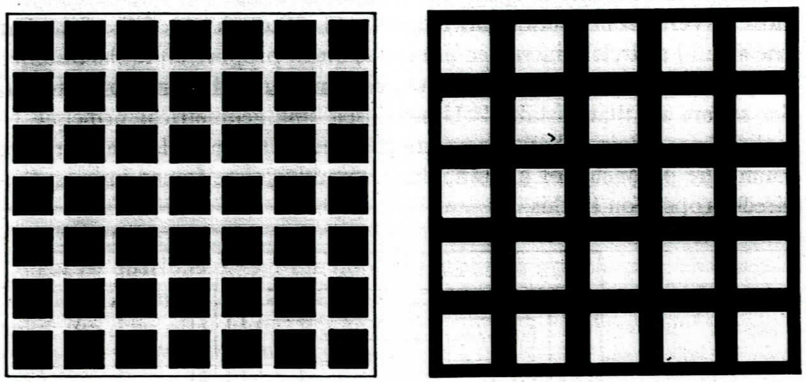


Fig. 1.6

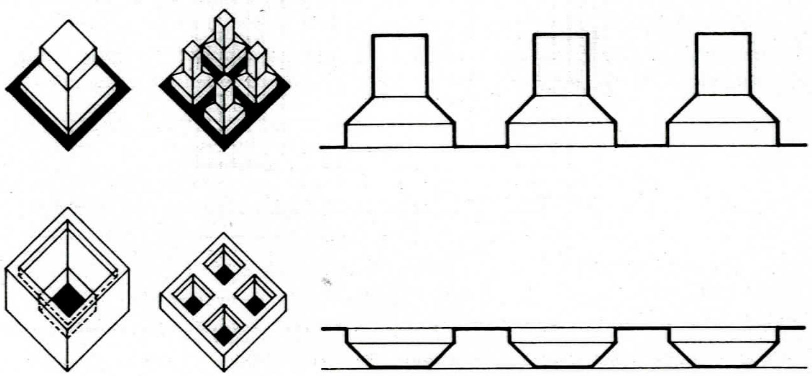


Fig. 1.7

This central square (which can be called the pavilion) and the outer annulus (which can be called the court) are two ways of placing building on the land. Let us now extend this. On any large site a development covering 50% of the site could be plotted as forty-nine pavilions, as shown in Fig. 1.6, and exactly the same site cover can be plotted in court form. A contrast in the ground space available and the use that can be made of it is at once apparent. But this contrast can be extended further: the forty-

nine pavilions can be plotted in a form which is closer to that which they would assume as buildings (that is low slab with a tower form over this). This can now be compared with its antiform: the same floor space planned as courts (Fig. 1.7). The comparison must be exact; the same site area, the same volume of building, the same internal depth of room. And when this is done we find that the antiform places the same amount of floor space into buildings which are exactly one third the total height of those in pavilion form (Martin and March 1966).

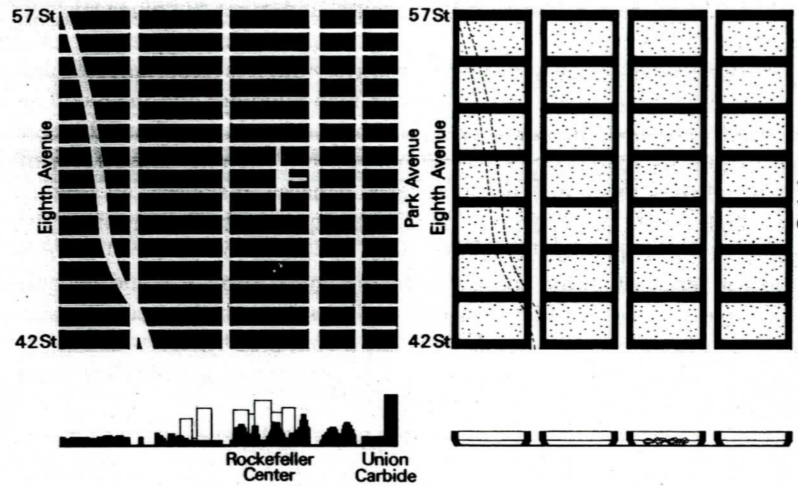


Fig. 1.8

This brings the argument directly back to the question of the grid and its influence on the building form. Let us think of New York. The grid is developing a certain form: the tall building. The land may appear to be thoroughly used. Consider an area of the city. Seen on plan there is an absolutely even pattern of rectangular sites. Now assume that every one of those sites is completely occupied by a building: and that all these buildings have the same tower form and are twenty-one storeys in height. That would undoubtedly look like a pretty full occupation of the land. But if the size of the road net were to be enlarged by omitting some of the cross streets, a new building form is possible. Exactly the same amount of floor space that was contained in the towers can be arranged in another form. If this floor space is placed in buildings around the edges of our enlarged grid then the same quantity of floor space that was contained in the 21-storey towers now needs only 7-storey buildings. And large open spaces are left at the centre.

Let us be more specific. If the area bounded by Park Avenue and Eighth Avenue, and between 42nd and 57th Street is used as a base and the whole area were developed in the form of Seagram buildings 36 storeys high, this would certainly open up some ground space along the streets. If, however, the Seagram buildings were replaced by court forms (Fig. 1.8) then this type of development while using the same built volume would produce buildings only 8 storeys high. But the courts thus provided would be roughly equivalent in area to Washington Square: and there could be 28 Washington Squares in this total area. Within squares of this size there could be large trees, perhaps some housing, and other buildings such as schools.

Of course no one may want this alternative.† But it is important to know that the possibility exists, and that, when high buildings and their skyline are being described, the talk is precisely about this and not about the best way of putting built space on to ground space. The alternative form of courts, taken in this test, is not a universal panacea. It suggests an alternative which would at once raise far-reaching questions. For instance, the open space provided in the present block-by-block (or pavilion) form is simply a series of traffic corridors. In the court form, it could become traffic-free courts. In this situation the question which needs answering is: at what point do we cease to define a built area by streets and corridors? At what point could we regard a larger area as a traffic-free room surrounded by external traffic routes?

In all this the attempt has been simply to give a demonstration of procedure. The full repercussions of the questions are not obvious. They are highly complicated. But the factual aspect of the study establishes a better position from which to understand the nature of the complication and the limits of historical assumptions. What is left is something that can be built upon and needed decisions are brought back to the problem of the built form of an urban area not merely of a building. Here, the choice of the built form is critical in a number of ways, not least as a means of securing a new unity of conception.

Take for instance the question of the size of the road net. Professor Buchanan has looked at this from another angle (Ministry of Transport, 1963). Looking at cities in relation to traffic, he saw that most of them are built up from a collection of localities. He called these 'environmental areas'. These areas are recognisable working units. They are areas in which

† It is simply a demonstration of a possible choice within a general strategy, such as that for instance proposed by the Goodmans (1960) in '*Communitas*' Appendix A. The Goodmans also suggest a change in the scale of the grid by street closure (1961) and note (1960 p. 230) that with better layout on the residential acreage of Manhattan every room could face onto a Madison or Washington Square.

a pattern of related uses holds together: local housing, shopping, schools, etc., would be one obvious example. These areas are recognisable in Manhattan just as clearly as they are in London. They form, in Professor Buchanan's terms, 'the rooms of a town'. They need to be served by roads but they are destroyed when roads penetrate and subdivide them. His solution was to try to recognise and define these working areas and to place the net of roads in the cracks between them. By estimating the amount of traffic that might be generated by the buildings in such areas, Professor Buchanan was able to suggest some possible sizes for the networks. He had in fact by this procedure redefined the grid of a town in terms of modern traffic.

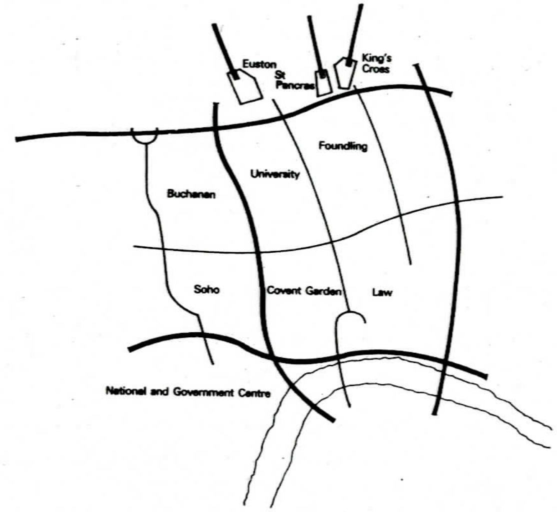


Fig. 1.9. Environmental areas and road networks as suggested by Buchanan.

Here then is a proposition for a framework within which we can test out some possible arrangements of the built form. Professor Buchanan selected St Marylebone as one of his test areas. This happens to adjoin the main London University site (already defined as a precinct in the London Plan) and this in turn is contiguous with the area around the Foundling Estate which has been used in some Cambridge studies of the built form (Fig. 1.9). All three areas are approximately equal in size. The Foundling area (bounded on the north and south by Euston Road and Theobalds Road, and on the west and east by Woburn Place and Grays Inn Road), is about 3700 ft from north to south and 2000 ft wide. It developed a cohesion of its own. How did this happen?

This in turn can be related back to the main line of argument. In 1787 the whole of this area consisted of open fields: there were no controlling features. A plan of 1790 divides the land into building plots by its network of streets and squares. The subsequent history, so well traced by Olsen (1964), shows the development and elaboration within this pattern. By 1900 the area could have been described by the language that Mrs Jacobs applies to Greenwich Village. The intellectuals were there: so were the working Londoners: so were the Italians around their hospital in Queen Square. There were handsome houses; tenements and mews; hotels and boarding houses. The area had its own Underground station and its own shopping area along Marchmont Street. It served a complex community.

By 1960 the balance within the original pattern had radically altered. Fast moving traffic using the small scale grid of streets had subdivided the area. Site by site residential development at a zoned density of 136 people to the acre produces only one answer: tall blocks of flats. Redevelopment of sites for offices created taller and thicker buildings. The hospitals, which needed to expand, were hemmed in by surrounding development. The pattern congealed.

In this situation only a new framework can open up a free development. And if Professor Buchanan's surrounding road net is accepted as a basis for the development of the environmental area, the problem can be seen within a new unifying context. What sort of advantages could a rearrangement of the built form now create? Professor Buchanan in his study area outlined three possible solutions with progressive standards of improvement. The merit of this is that it sets out a comparative basis of assessment. But even his partial solution leads to an extensive road and parking system at ground level. From the point of view of the pedestrian the position is made tolerable by the use of a deck system to create a second level. Above this again, some comparatively tall buildings are required to rehouse the built space that is at present on the ground. This kind of image of the architecture of cities has a considerable history in modern architecture and has been much used as an illustration of central area reconstruction. But, as Professor Buchanan himself asks, what building complications does it produce and what sort of an environment does it create? Is it in fact worth building?

Professor Buchanan's range of choices could in fact be extended by applying some of the theoretical work which has been described. And when this is done the results are significantly different. The boundaries of the total area that are being considered have been defined by this new scale of the road network: the grid. Within this, the existing floor space can be assessed (Fig. 1.10): 34% of the site is occupied by housing: 25% by roads: 15% by office and commercial use: 12% is open space. In addition there is

an important shopping street, a major hospital and several schools and educational buildings. With this information available it can be considered at a theoretical level how this might be disposed in a new building arrangement.

First, the shopping street, Marchmont Street, could be established as a north/south pedestrian route associated with the Underground and some housing. If all the office space which is at present scattered throughout the area could be placed in a single line of buildings around the perimeter of

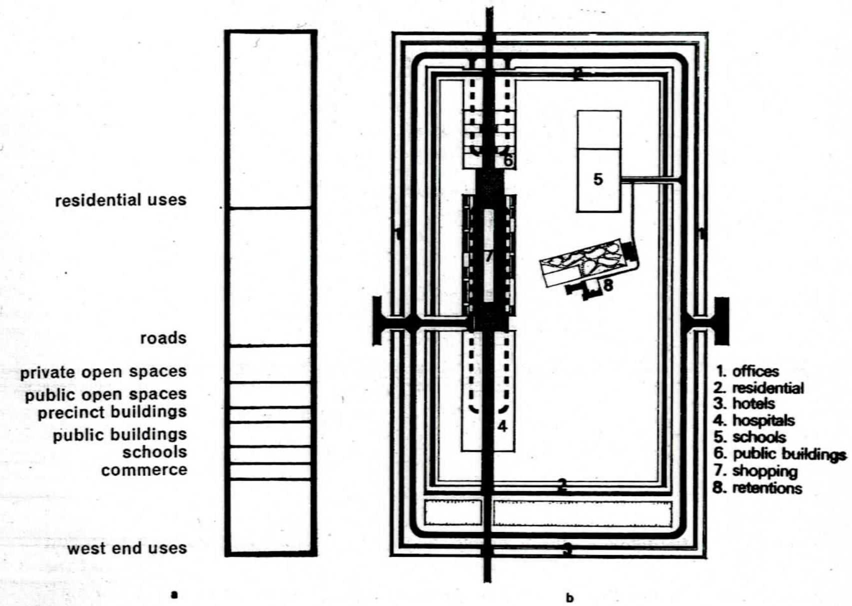


Fig. 1.10a. Quantities of built and open space in the Foundling Area.
Fig. 1.10b. Possible geometric layout of the same quantities of built space in perimeter form.

the area (where some of it already is), it need be no higher than eight storeys. All the housing at present in the area could be placed within another band of buildings sited inside this and no higher than five storeys. Of course it could be arranged on the ground to include other forms and types of housing, But in theory, the bulk of the building at present covering the area could be placed in two single bands of building running around its edge, leaving the centre open, which would be a park-like area about the same size as St James's Park (Fig. 1.11). Precisely the same

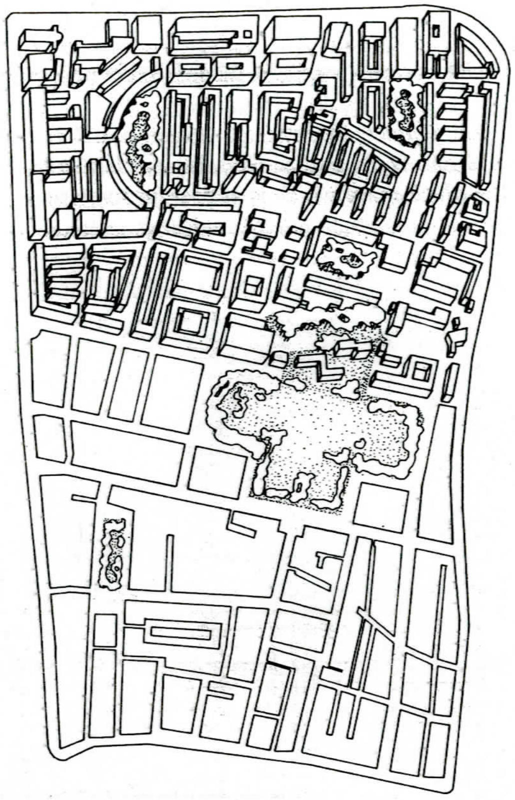


Fig. 1.11a. The existing plot layout and building development in an area of London that might be regarded as an environmental room. But it is sub-divided by roads and the limited size of the building plot increasingly forces development upward.

amount of floor space would have been accommodated. There need be no tall buildings, unless they are specifically wanted. All the housing could look onto a park. Buildings such as schools could stand freely within this. There would be a free site and a park-like setting for new hospital buildings.

All that may sound theoretical and abstract. But to know what is theoretically possible is to allow wider scope for decisions and objectives. We can choose. We can accept the grid of streets as it is. In that case we can never avoid the constant pressure on the land. Housing will be increasingly in tall flats. Hospitals will have no adequate space for expansion. Historic areas will be eaten into by new building. A total area once

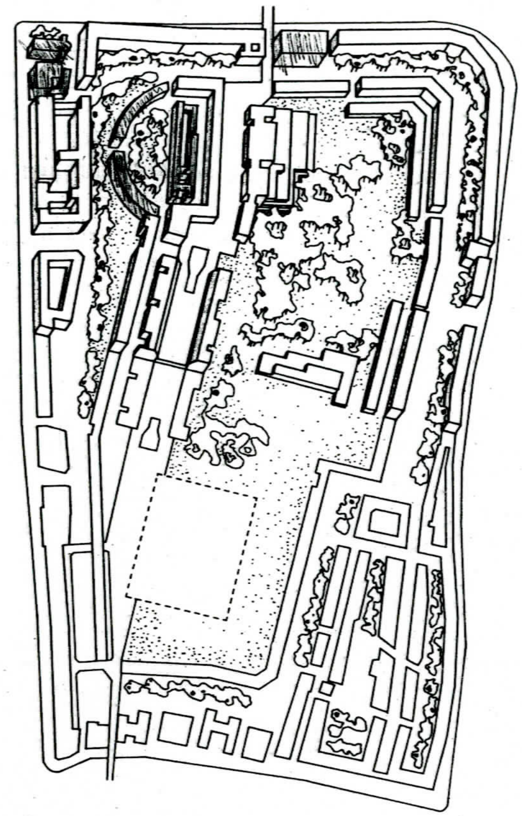


Fig. 1.11b. The same area as that in 1.11a. The road network is now enlarged and runs around the boundary of the area. Theoretically an entirely new disposition of buildings is possible and the illustration shows exactly the same amount of floor space in a new form. Tall buildings are no longer necessary: the buildings themselves have a new freedom for development and a considerable area of open space is discovered.

unified by use will be increasingly subdivided by traffic. We can leave things as they are and call development organic growth, or we can accept a new theoretical framework as an outline of the general rules of the game and work towards this. We shall know that the land we need is there if we use it effectively. We can modify the theoretical frame to respect historic areas and elaborate it as we build. And we shall also know that the overlapping needs of living in an area have been seen as a whole and that there will be new possibilities and choices for the future.

2. *Speculations*†

LESLIE MARTIN, LIONEL MARCH & OTHERS

In the 1920s an important shift of architectural intention and process – a shift of social attitude – became clear. However complicated the historical situation may have been, three powerful lines of thought appeared. The first came from the passionately held belief that there had to be some complete and systematic re-examination of human needs and that, as a result of this, not only the form of buildings, but the total environment would be changed. The second line of thought, interlocking with this, was simply that change in the form of buildings, or environment, would only be achieved completely through the full use of modern technology. These two ideas produced a third, which was that each architectural problem should be constantly re-assessed and thought out afresh (Wurster 1965).

Now it is clear that no single one of these principles was ever completely demonstrated. They remained lines of action sometimes followed up separately, sometimes together. The rational examination of needs went some way, certainly, towards a fundamental change in the plan form of buildings. But of technical innovation, there was not a great deal. There was a lot of talk about the machine but its end products were not very evident in buildings. What the designers saw, often in a confused way, were the possibilities that arose from their beliefs and attitudes, and it is around these anticipations that they built up their formal systems. In this sense their buildings were symbols of what a new architecture might be. And for their day they had an immensely powerful meaning.

All this is something very different from an attempt to produce new forms as a primary objective: i.e. as a kind of rootless formalism. What

† This essay is a compilation from many sources. The introductory pages are from an article by Sir Leslie Martin entitled, 'Architect's Approach to Architecture', published in the *R.I.B.A. Journal*, May 1967. It introduces paraphrased excerpts from other papers and articles which are here presented as 'Speculations'. The word is fitting as the attempt was to raise questions which could only be answered by subsequent formulations.

seems to be important about it are the intentions that caused these forms. The difference between a chair produced by the arts and crafts movement and a chair designed by Rietveld is not just a difference of form. The form comes from a different emphasis on who makes it, on how it is made and how many people can have it. Now to stress this distinction is to make a declaration of attitude. The design of an object becomes a statement of conviction about what a society may need, the way it might consider its surroundings, the kind of products that it might have and how it might manufacture and use them. It is indeed an intellectual commitment; and this attitude of mind will apply equally to any aspect of design. The work resulting from the 1920s and 1930s is of interest and value today because of the ideas that it embodies (Wilson and Rowe 1965).

The change from art and craft intuition towards rational analysis, measurement, technical innovations and speculative thought about these things, is one manifestation of this. The change is there at an early date in the opposition to the intuitive craft approach, and in buildings that are 'built to a purpose' and thought out, rather than drawn. It is this matter-of-factness in which the act of design cannot be separated out as a form-making process that remains central. It is re-echoed in the various catch-phrases around which theory (and particularly German theory) was discussed.

But history is never clear cut. Against this attempt to reintroduce rationalism as a basis for architecture, there is, all along the line, the opposition of a powerful wing of 'individualist' creators. The situation is confused. Rational thought about needs and processes by one school was in some way considered by another to be dangerous and inhibiting. Practical reason and intuition were seen as opposites. And it is also true, as C. B. Wurster (1965) and J. M. Fitch (1965) have noted, that just as the products of practical reason were being demonstrated on an impressive scale in the housing projects of Holland and Germany, the developing theory became dogma. The principle that rational thought about use and construction must produce (as an integral part of this process) its own formal systems required a continuous reassessment of every aspect of a problem. Knowledge would be established by analysis, advanced by experiment and confirmed or corrected by test. A ruthless reassessment of each achievement was an essential part of this process. But, in that important and major housing achievement of the 1930s, the process stopped. The speculative thought that could have extended the range of built forms into totally new environments dried up. In Germany and elsewhere the set housing solution solidified into parallel rows of slab blocks.

The fact that this happened was of enormous consequence. The rational

approach was at once suspect. The end result of practical reason appeared to be sterility: and it was assumed that this could be countered only by intuitive processes – by feeling. Thus the old nineteenth-century oppositions were continued.

What was wrong with parallel slab layout was not the rational thought that it contained, but the failure to extend this by further speculative, formal invention. As A. N. Whitehead (1929) once pointed out, it is speculation that makes rational thought live: and it is rational thought that gives speculative invention its basis and its roots. To analyse, to measure and to rationalise the problem is an essential part of the process of scientific thought. And, in the scientific process, intuition (or what Alfred North Whitehead (1929) prefers to call conjecture or speculative reason) is itself entirely arbitrary unless it is guided by thought or system. Practical reason is the means by which methods are developed for dealing with different kinds of facts. Speculative reason is an extension of this into theoretical activity. Progress depends on a lively interest in speculative reason. Through the interaction of these two forms of thought, factual assessment can take its place within an overall scheme of things: speculative reason is 'robbed of its anarchic character without destroying its function of reaching out beyond set bounds' (Whitehead 1929, p. 66). Whitehead goes on to add that the massive advance of modern technology is due to the fact that these two forms of thought (rational and speculative) have again made contact. That, translated into architectural terms, is equivalent to saying that the rational understanding of a problem and the extension of this into speculative (intuitive) thought is one single process: that is, that thought and intuition are not opposed but complementary. We may recognise at once an older (pre-nineteenth century) concept of architecture in which the design process cannot be isolated from the thought processes by which the problem is analysed and solved.

The decisions that are taken about the planning of buildings, their form and the grouping in relation to the land available may be based on assumptions which appear to be eminently sensible and rational. However, rigorous reassessment – despite the initial form of refutation that it might assume – will always prove productive. The argument presented here is that things are not always what they seem to be. Refutation can begin as an intuition of imposture; but to prove that, speculation and rational formulations must be able to demonstrate first the fallacy and then alternative and more useful deployment. The fallacy may exist at any scale: of site resources assumed to be needed, of the relationship of rooms within the building to the corridor space connecting them, of grouped buildings to each other and to each other's uses, of buildings within the city and the streets by which they are connected.

It is particularly fortunate when out of speculation, research has its beginnings. The points here raised were formulated out of a series of separate studies as they arose from practical problems. Since they were not contained within a formulated body of theory they can best be described as speculations.

Speculation 1 (Martin & March 1965)

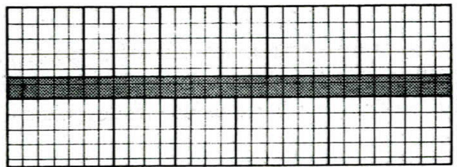
How can we study the efficiency of the planning of buildings? There is a common assumption that the most economic building is that in which the circulation space is reduced to a minimum when set against the total floor area: that is to say that maximum efficiency of planning is measured by the relationship of circulation to gross area. This measure is frequently used in assessing costs and awarding grants. At the same time other standards, possibly conflicting, may be introduced, for example room sizes based on increments, or constructional sizes resulting in modular dimensions. These are all interrelated factors and the interaction can be studied in a few simple diagrams.

In the example selected, 12 rooms have to be accommodated. These vary in size and their areas are based on graded increments of 25–50 sq ft. The planning and structural module is based on a 4-ft grid. In the first layout (Fig. 2.1a), the rooms are arranged along each side of a minimum 6-ft corridor, in what may be considered to be an efficient plan. The rooms are made 18 ft deep and arranged in length to form the most convenient fit between the incremental sizes and the planning unit. There is a clear over-allocation of floor space per room: the area increment being 72 sq ft instead of the required increment of 25–50 ft.

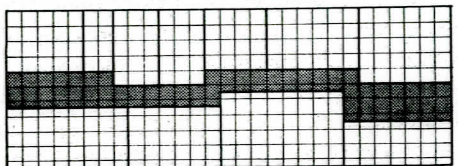
In the second diagram (Fig. 2.1b), the variation in room size has a two-way freedom, the depth of the room being controlled by the 4-ft module. The room over-allocation is reduced. The corridor is increased in space in what might appear to be a wasteful manner, but the total floor area remains the same as in the first example.

If the module for room depth is now reduced to 2 ft (Fig. 2.1c) then room allocation has a tighter fit. The corridor width is 8 ft over 80% of its length and may be more pleasant and at the same time more useful by accommodating waiting areas or filing space.

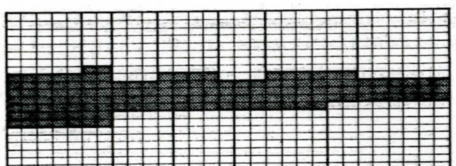
In the previous examples the building block is 29 units in length and 10½ in width. The effect of an increase in the width of the block can now be considered. In the next diagram (Fig. 2.1d), with the block now only 21 modules long and 14½ modules deep, a 6-ft corridor is again introduced. The over-allocation is now the highest in the series. The circulation area is the least and the external face is 16 modules less than in the previous examples.



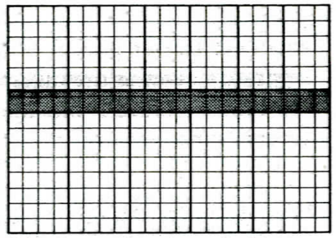
a. 4 ft-module, minimum corridor width: overentitlement of room area



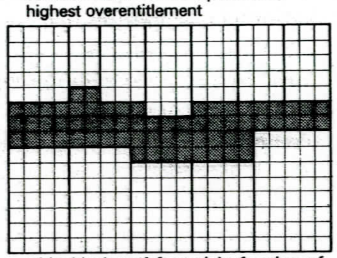
b. 4 ft-module, freedom of corridor width: reduction of overentitlement



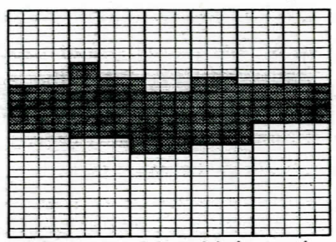
c. 2 ft-module increased circulation area: better entitlement fit



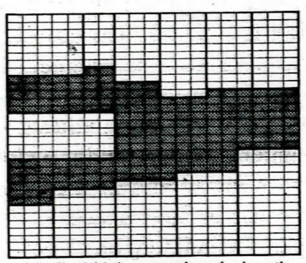
d. block proportions changed, minimum corridor width: reduced perimeter, highest overentitlement



e. wider block on 4 ft-module, freedom of corridor width: closer entitlement fit



f. wider block on 2 ft-module, increased circulation area: exact entitlement fit



g. block width increased again, length decreased: exact entitlement maintained, area utilisation increased, perimeter decreased, worst ratio of circulation area to gross area

Fig. 2.1. A comparative study of office layout with varying planning modules, room depths, and perimeter lengths.

If the rooms are now given freedom in depth and the depth is controlled by the 4-ft module (Fig. 2.1e), the room entitlement has a closer fit and the corridor is nowhere less than 8 ft wide. With a further reduction of module depth to 2 ft (Fig. 2.1f), there is no over entitlement and nowhere is the corridor less than 10 ft. When the block is widened again to 16 modules (Fig. 2.1g) the increased depth allows a conference room to be inserted in the central area. The external perimeter face is reduced from 42 modules to 38. By some criteria this layout is the best, though it has the least favourable circulation to gross area ratio (26.6%) in the series. It gives a perfect fit of entitlement to allocated space, has the least external wall surface (perimeter length) and the least gross area. The ratio of circulation to gross area as a measure of efficiency can certainly be questioned.

Speculation 2 (Martin & March 1965)

Many measures of the 'efficiency' of buildings may be developed but these can only be of use when they can be seen in relationship and when values can be defined in measurable terms. It may be asked, for example, what building forms make the best use of land? The question necessarily involves a value judgement of what is meant by 'best use' and this can only be answered objectively insofar as the values can be defined in measurable terms. It might be assumed that current planning controls, where they use measures, will supply an answer and that the question is asked wherever a development is proposed for a given site.

Current planning techniques, in fact, offer two measures which have dominated planning and architectural action for many years. The first is a measure of floor space index (or its alternative plot ratio) and the second is concerned with daylight considerations.† These two measures are assumed to provide a rational relationship of floor space to site and an assurance that buildings will be adequately lit. The use of the first measure has sometimes been extended to give an indication of the population accommodated in the buildings.

Martin, March and Taylor (1965) examined this last point by producing a set of graphs to show the relationship of three of the factors which may be considered in determining the population capacity of a given site. (These graphs are illustrated in Fig. 2.2.) In relation to a typical site area of 100,000 sq ft the plot ratio may be 2:1, 3:1 or 4:1. This generates floor areas of 200,000, 300,000 and 400,000 sq ft (Fig. 2.2a). The gross

† Floor space index is the gross floor area measurement of the building including the thickness of the external walls; this total is divided by the site area including half the width of the surrounding roads. Plot ratio is the same gross measurement of floor area divided by the net site area. These measures are expressed as 2:1, 5:1 etc. Daylight considerations are measured by special protractors and nomograms.

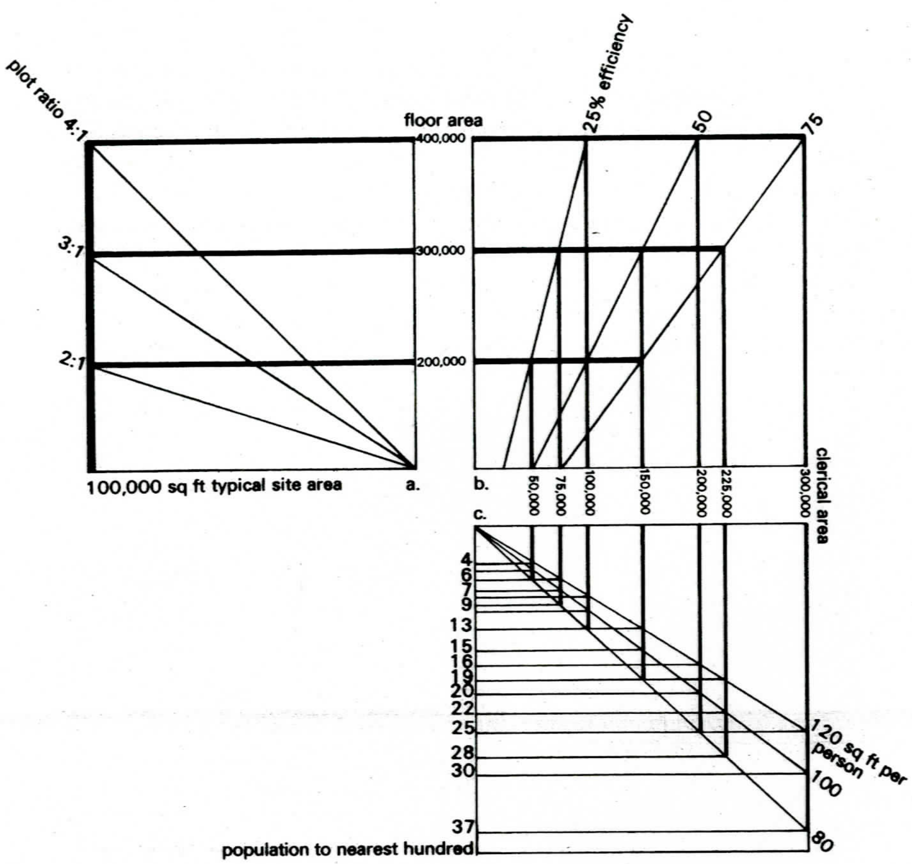


Fig. 2.2. Range of population density as function of plot ratio.

floor area may then be used with varying degrees of efficiency, for example 25%, 50% or 75%. The clerical areas generated from these (Fig. 2.2b) yield nine possible results ranging from 50–100,000 sq ft at 25%, 150–200,000 sq ft at 50% to 150–300,000 sq ft at 75%. If these possible clerical areas are now related to an allocation of square feet per person (Fig. 2.2c) this too may fall within allowances of 80, 100 or 120 sq ft per person. In this example seventeen different populations ranging from 400 to 3700 could arise from the same site area as a result of these relationships of plot ratio, general plan efficiency and floor space allocation per person.†

† Other factors will clearly limit this range, for instance, building codes. Similarly, land and development costs, particularly in central business districts, will tend to secure intensive use. But coordinated relationships between bulk and density and use and density are not usually even formulated.

It is clear that plot ratio in itself is no satisfactory measure of population, though it is useful as an assessment of the total floor space provided by buildings on any given site in any area of a town.

Speculation 3 (Martin & March 1966)

But continued scrutiny can go on to reveal whether this plot ratio measure will insure in any way that the site area will be effectively used. In order to demonstrate this we might place on any given site parallel rows of 4-storey buildings spaced apart by a conventional light angle of 45°: in this case the plot ratio will be 2:1. If however the building remains at 4 storeys but is arranged as a solid block lit by courts, in which the prescribed light angle is still used, the plot ratio will increase from 2:1 to 3:1, that is by a factor of 50%. Assuming for a moment that both forms of building lend themselves equally to internal planning, it becomes clear that the building form can have a pronounced effect on the total floor space possible on any given site. If urban land is to be developed economically and if reliable measures of this are necessary, it is desirable to know which forms of building appear to make the most effective use of ground area.

In approaching this question we are at once confronted with some deeply embedded ideas. One of these, for example, is the prevalent notion that high tower buildings are necessary in order to use land efficiently. Tower buildings have been used indiscriminately in London on sites which differ considerably in both size and surroundings. Any form of building is permissible within the measure of floor space index. If certain limits are set, such as size of site, the amount of floor space required, the acceptable depth of building, the amount of floor space with outlook, the amount without and so on, it is possible to demonstrate that a development might assume many building forms including tall towers and that a very considerable number of variables exist and a wide range of choice requires examination. In one case studied with six co-ordinates, this reached a total of 60,000 possible solutions.

Speculation 4 (Martin & March 1966)

How can such a problem be studied in a systematic manner? The site utilisation of various layouts can be studied by classifying the built forms under three headings: the pavilion or tower, the street and the court. These can be considered within a rectilinear universe. The pavilion is finite in its plan form. The street extends, potentially, infinitely along one axis. The court extends infinitely along two. From these built forms rectangular lattices can be derived. In fact the pavilion, the street and the court consti-

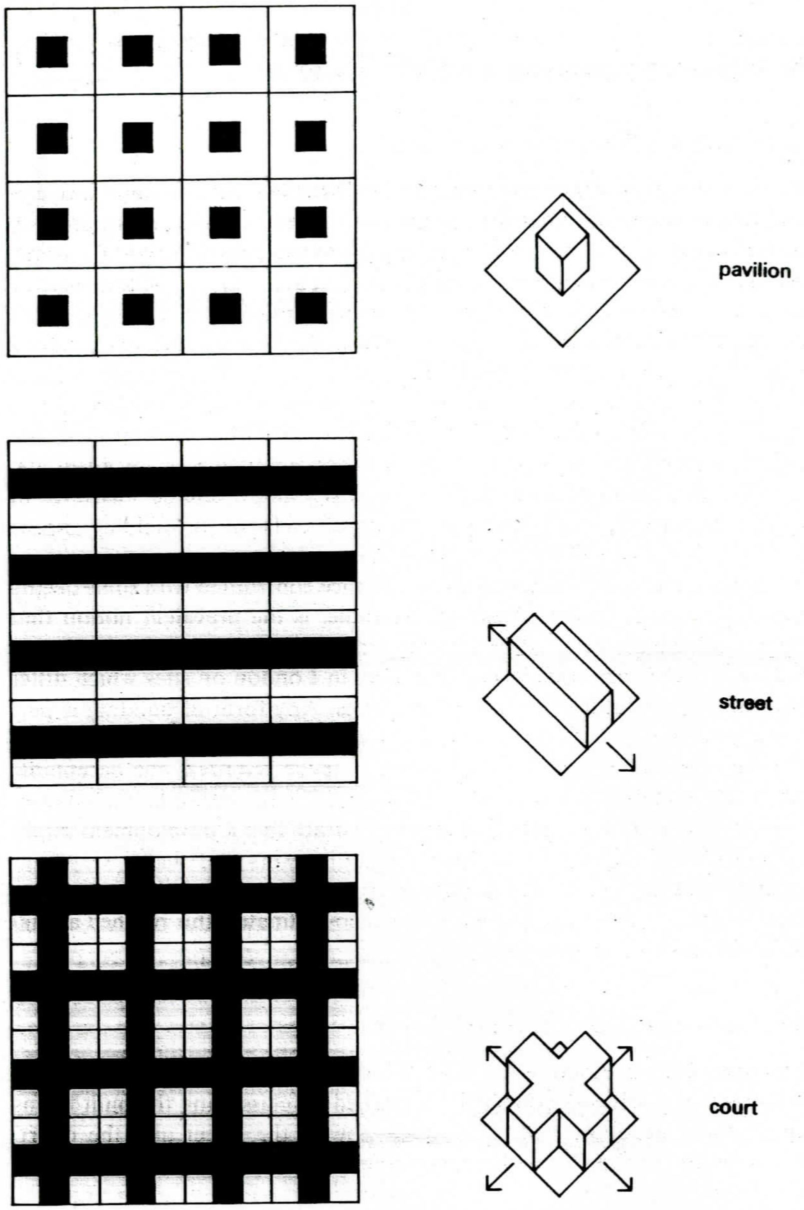


Fig. 2.3. Schematic diagram to show three different dispositions of built forms: pavilion or tower, street or slab, and the generating cruciform in a continuous pattern of courts.

tute points of recognition in what may more properly be seen as a continuous transformation from one extreme to the other (Fig. 2.3); from an array of isolated blocks elongated into continuous parallel rows, and these joined in the perpendicular direction to form a net of courts.

This can now be examined. The co-ordinates used must be constant for each case: the same site area, the same block depth, the same width of interspace, the same floor height, etc. Two factors reveal certain aspects of the problem: one is the site utilisation factor, that is the ratio of the site covered to the area not covered. The other is the built potential, that is the ratio of the floor area of the built form to the site area.

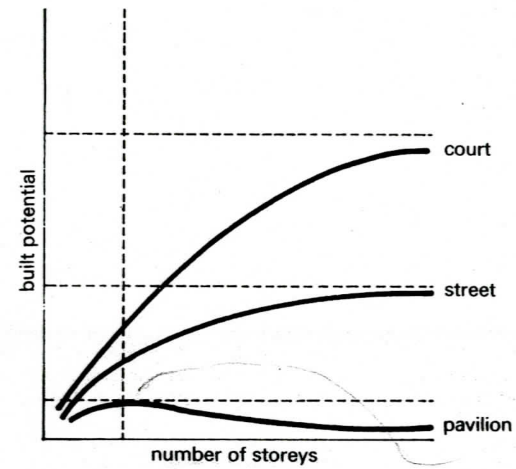


Fig. 2.4. Built potential in relation to number of storeys.

When the built potential is plotted against the number of storeys for each one of the three built forms described, assuming all other factors are constant, then it is seen that after a certain height the tower form ceases to use land with increasing efficiency and lower towers more closely packed together, but with no change in the angle between contiguous towers, will give the same degree of built potential. (Fig. 2.4) This could be one reason that the 'City of Towers', free standing towers in a park-like setting, has never been built. It is inherently inefficient in terms of land use. In comparison to the pavilion or tower form at its maximum, the built potential of the street form has twice its value, and the built potential of the court form is no less than three times as great.

The form of a typical high density development, a low podium surmounted by a tower, corresponds closely to the building envelope obtained by using daylight protractors. Day lighting controls have determined to a

large extent the massing of building seen in the central city of today (Watts, 1963). The type of study described can be developed by considering pyramidal forms which approximate more closely to the actual building form (Fig. 2.5). This generalised pavilion form may again be compared with its antiform, the court. When this is done, the court form is seen to place the same amount of floor space on the same site area with the same condition of building depth and in approximately one-third the height required by the pavilion form.

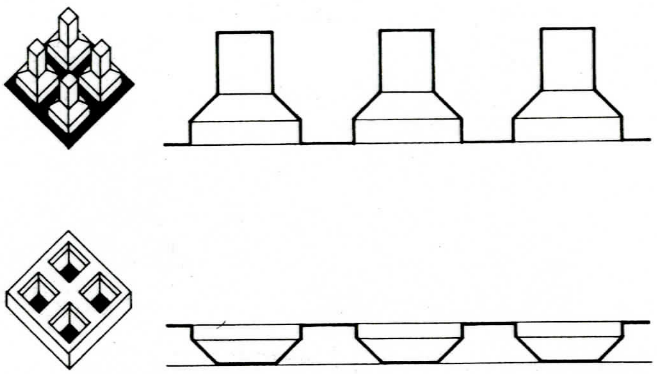


Fig. 2.5. Generalised pavilion form and its antiform; modified antiform of the generalised pavilion form at the same scale and containing the same amount of built volume on the same site; the heights are approximately in the ratio of 3:1.

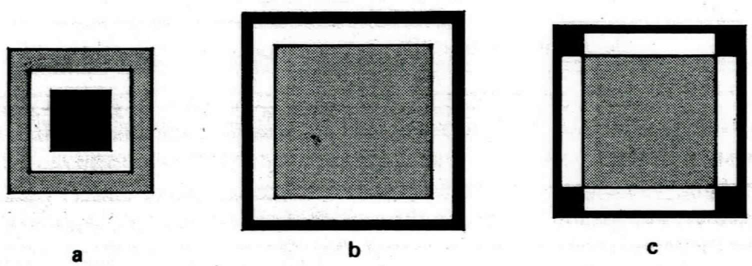


Fig. 2.6. The illustration shows (a) a pavilion development and (b) and (c) court developments, in which several proportions of site utilisation: coverage, built potential (bulk) and percentage of floor area without outlook, are the same. For the same number of storeys, the built potential will be the same for all three buildings. The different size site area needed to equalise these proportions suggests that each form has an optimum site size. (Fig. 2.6c takes into account the internal angle condition required to maintain the proportion of floor space with outlook, while building the court form on a smaller site.) Black areas represent floorspace without outlook; white areas represent floorspace with outlook; tinted area represents that part of site uncovered by development.

Speculation 5 (Martin & March 1966)

What is to be observed, however, is that if the built potential is held constant for the pavilion and the court, and if the proportion of the built form having outlook and that with no outlook is again constant, then the size of the site for these two developments will differ (Fig. 2.6). This seems to suggest that each form of development probably has its own optimum size. If the highest densities were to be allowed only on the larger sites, then it appears to be the case that high and deep buildings would be unnecessary in terms of land use, though they may be required on other functional grounds. This kind of consideration could lead to the general loosening up of the texture of building on ground space. In that case a new relationship



Fig. 2.7a. A 50-acre site developed with typical bye-law streets at a density of 100 persons per acre.

of building to road must be sought. The development of larger areas of land and the possibility of buildings occupying less ground space offers the possibility of a new scale of road network in which the interrelationship of land, building content and the traffic which it generates is made more balanced.

Speculation 6 (Martin & March 1968)

This question of the relatedness of things is central to the consideration of any single issue like the provision of housing, schools, open space or the roads by which they are served. All these things are aspects of the main problem of relationships: and by looking at a question in this way the old barriers created by zoning are immediately removed.

Professor Vaizey (1968) once stated that the older areas of towns may continue to have the oldest schools. The problem, he said, was that even if the housing priorities did not eliminate them, the larger sites which they tend to demand displaces the stock of housing.

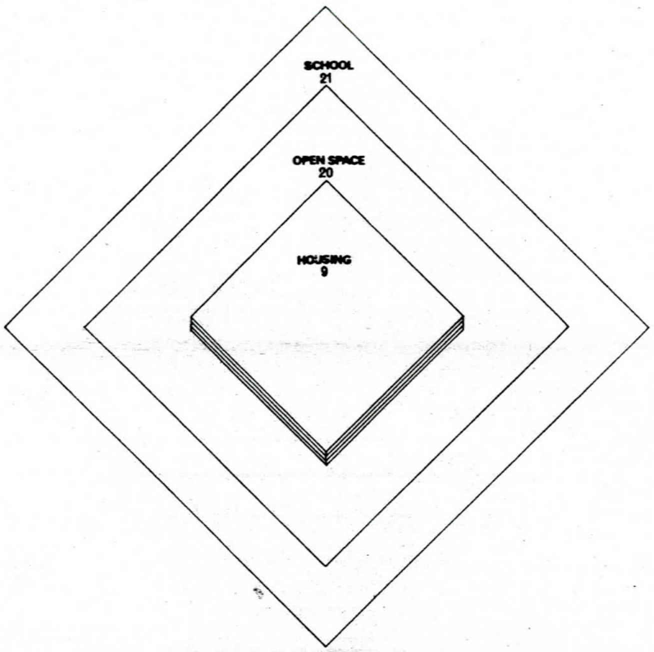


Fig. 2.7b. The land-use requirement of the 5000 people housed on the 50-acre site. The area allocated to schools includes 7 acres for buildings and 14 acres for playing fields. When an allowance is also made for open space, only 9 acres remain for housing. The housing floor area is 3 times that of the land available.

It could be argued that educational need and housing need cannot be separated: both are part of the larger theoretical problem of how we use land by buildings. When the issue is considered in this light the results are sometimes surprising. Consider an area of land in a nineteenth-century industrial city: suppose that there are 50 acres of by-law street housing inside a frame of busy commercial and shopping streets. (Fig. 2.7a). The

residential density is 100 persons per acre. Assume that there is one obsolete primary school embedded in the housing; most of the children attend schools elsewhere. Now consider the rebuilding of this area. Can houses be provided for the present population at the same time that schools are made available for its children? There appear to be competing land uses, and in any rebuilding there may be the added requirement of public open space.

Let us look at this from the point of view of schools. Fifty acres generate 5000 people, and these in turn might demand an infants' school for some 300, a junior school for something over 400, and for the sake of argument

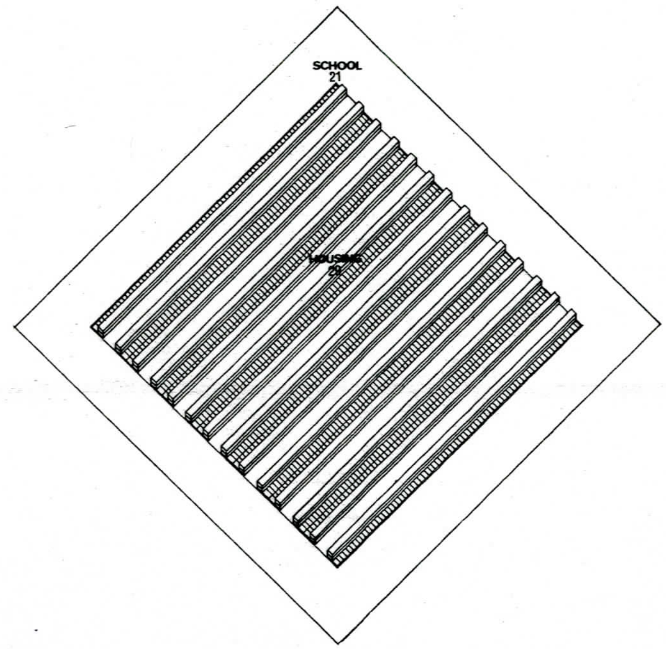


Fig. 2.7c. If the schools are accommodated, and this open space omitted, there remain 29 acres of land for housing. 3600 people could be accommodated in 2-storey housing arranged in the simplest possible way. 5000 people would require most of the site.

we may assume also a secondary school of around 600. The school buildings alone would occupy 7 acres of land. Playing fields will require an extra 14 acres. Altogether 21 acres, or 42% of the land, would be required for educational purposes. If another 4 acres per thousand were to be claimed within the area for recreational needs, then 41 of the 50 acres or 82% of the land would have been pre-empted, and the housing would have to take place on the remaining 18%, on which again there would be some demand from access roads. In terms of sheer space the housing would occupy a solid block of building three storeys high (Fig. 2.7b).

It certainly looks as though Professor Vaizey is right. It appears to be a matter of *either* housing *or* schools, but not both. But the quantification immediately draws attention to an important issue. Why is so much land needed? What is it that demands an area large enough to allow the simultaneous use by over 100 pupils playing five different soccer matches at the same time? What about overlapping uses of recreational land by a far wider range of activities – in farming terms, a double or triple cropping of the land? And if the school land were available to the locality or, as recom-

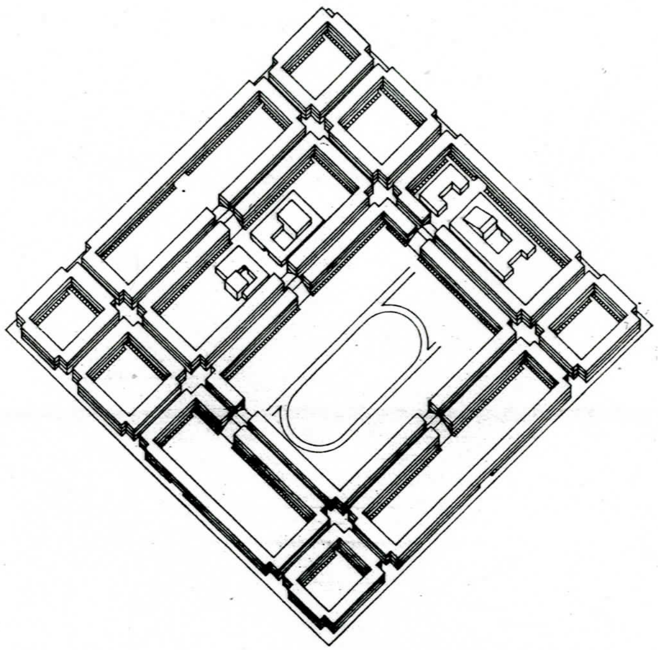


Fig. 2.7d. Three-storey housing would require 25 acres of land including roads and small 'outdoor' room space. This housing is only possible if the 21 acres of school land and the open space allocation are used to form 'urban rooms' of varying size.

mended by the U.S. Sub-Committee for Environmental Standards (American Public Health Association), if the schools used the recreational facilities provided for the neighbourhood, what saving of land would then be possible? It is clear that we have a choice: if we were to consider these relationships, Professor Vaizey's problem might still be soluble.

But this can be looked at too from another angle, that of housing. A 50-acre site redeveloped at 100 persons per acre could be completely covered with houses and their attendant roads (Fig. 2.7c). In this case there would

now be no sites for schools. But we now know that this type of layout is only one point of recognition in a spectrum of dispositions of built form on the land. This primitive layout shows housing for 3600 people in two-storey houses and 21 acres for school sites. But if some sharing of the school land and open space were acceptable, this combined-use land (Fig. 2.7d), could provide 'urban rooms' within the layout and the new distribution of built form could accommodate the total population of 5000 in three-storey houses. This corresponds approximately to the layout of some of the squares in Bloomsbury. (Fig. 2.7e).

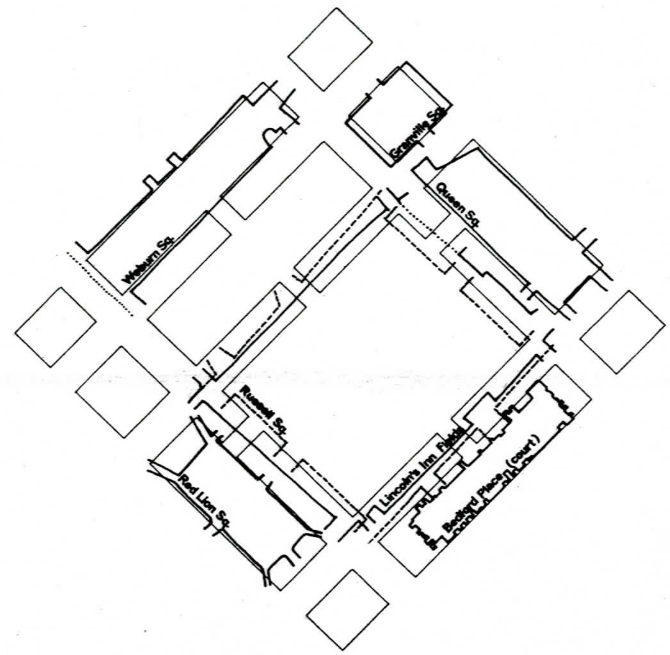


Fig. 2.7e. The 'urban rooms' compared with open spaces in the Bloomsbury area of London. Note that most of the buildings around the London squares exceed 3 storeys in height.

Accept another point in the spectrum and place the housing round the edge of the site (Fig. 2.7f and g): the total population of 5000 could be housed in narrow-fronted houses or flats, four or five storeys high around the perimeter of the site. They could all overlook and have available for use, a band of open space 180 ft wide and at the centre of this the 21 acres of land required by the schools. In this case both the housing and the schools could be provided.

Is it now preferable to accept a housing solution of this kind in order to find land for the schools? Is it really unacceptable to have a condition rather like that of overlooking Parker's Piece in Cambridge from some four or five-storey terraces around it?† (Fig. 2.7h.)

The proposition set by Professor Vaizey is clearly not insoluble. Both the housing and the schools can be sited, but not without adjustments within a total framework.

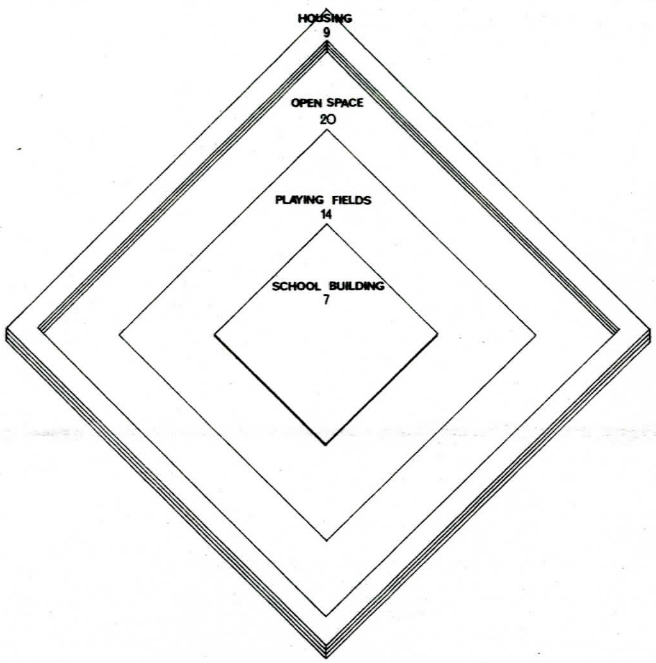


Fig. 2.7f. The housing area is now placed around the perimeter. If all other land uses are satisfied there remain just 9 acres of housing land.

Speculation 7 (Bullock, Dickens & Steadman 1968)

The lattices that can be built up around the 'pavilion', the 'street' and the 'court' forms (Bullock, Dickens and Steadman 1968, p. 104) are not arbitrarily chosen, but within the context of rectangular geometry, and treating prismatic forms only, they constitute the entire range of possible

† The results appear to be very simple. But it is curious that the forms of the layout described do not seem to have been built: at least not recently. Architects tend to think of housing in terms of building types: point blocks, slabs, maisonettes rather than land use built form relationships which may generate new types.

regular space-filling arrays. Despite their abstract geometry they indicate universal characteristics of the ways in which buildings use land and the forms are ones to which many actual buildings in the real world approximate.

In the development of this work March and Trace (1968) have formulated a mathematical description of built forms making it possible to give a standard notation to the geometry and other significant factors of these rectangular prismatic forms. This work has also been extended by the differentiation between perimeter space, that is unobstructed space around the building's edge, and core space which has refined the basic study.

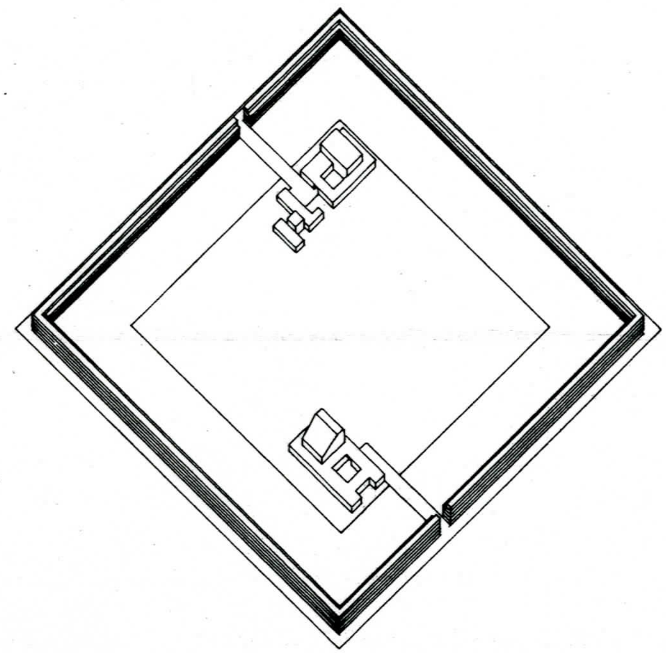


Fig. 2.7g. A 4½-storey narrow-fronted housing band could accommodate 5000 people at a density of 500 persons per acre. But they would all look out onto a vast open space: the perimeter open space is 180 ft wide and at the centre is the 21 acres of school land.

Nevertheless, evaluation of these basic forms is possible only in the simplest terms. The performance of forms may be compared, for example, in terms of the amount of land that they require to provide the same floor area: or the ratio of perimeter space to core space may be measured for different forms. Very general cost comparisons can be made by treating the cost of each building as a simple factor of the total floor area or by at-

tempting to weight the costs to take account of the ratio of floor area to roof area, and of floor area to perimeter walling in order to give a limited understanding of the changes in cost with the change in form.

Such measures of performance are crude, however, and may provide the designer with information too coarse to use in modifying his preliminary hypothesis or even to allow him to detect the effect of many decisions. What is needed is a library of factors considered in such a relationship that a change in any one of the parts is immediately seen in its effect on all the others. This is something that the designer is usually unable to do and

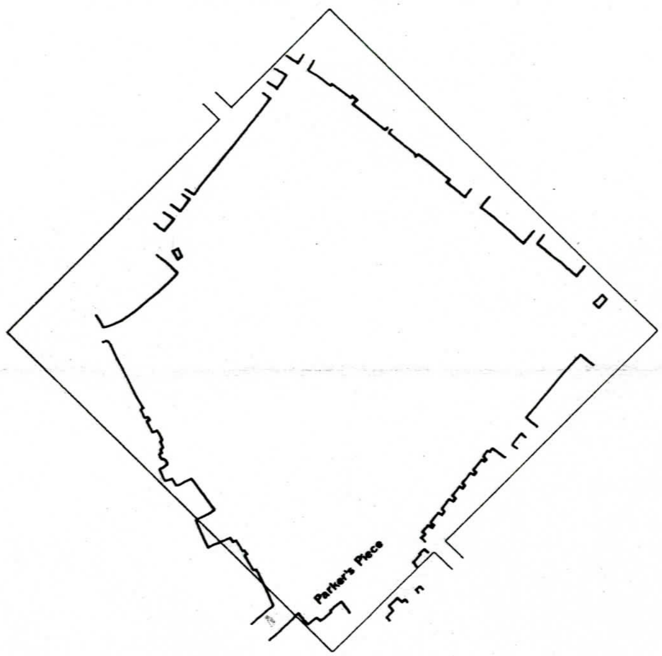


Fig. 2.7h. The central open space in Fig. 2.7g compared with Parker's Piece in Cambridge.

adjustments to design are made on the assumption that the change is largely independent of all but the most obviously related factors. The interdependence of the parts of the design problem and the validity of breaking the problem down into manageable but relatively independent parts has been studied by Christopher Alexander (1964). His work on the 'pattern of the content' seems essential as a first step to a consideration of the pattern of the form which is the problem that we are dealing with here. The total work of architecture is essentially concerned with the 'fit' between these

two considerations in themselves and the technical methods through which their requirements are met.

In order to monitor back to the designer information of sufficiently 'fine grain' to illustrate the real effect of the design decisions on the building, or to compare the 'fit' between activities and alternative building solutions, it must be possible to make a systematic transformation, not only of the overall form of the building, but also of the different elements of the building. It must be possible to compare not only different building forms but alternative room layouts, alternative structural and servicing systems and alternative circulation systems in sufficient detail to trace the consequences of these choices on the performance of the building in relation to the activities which it serves. That is the problem that needs systematic formulation if we are to increase our understanding.

Speculation 8 (March 1967)

The systematic study of the pattern of the form is relevant to the building, to the group of buildings and to the city or the urban region. And it is equally revealing in each case.

Figure 2.8 is a version of Howard's cluster of towns forming a city federation of 250,000 persons. By the year 2000 we would need 250 of these clusters to accommodate the whole expected population of England and Wales. Suppose for a moment we built these clusters and demolished everything else. 250,000 people would live in easy reach of one another and all social facilities. Schools would be within walking distance of all homes. Shopping would take place indoors. Everyone who wanted to would have a house and garden. The minimum plot size is 20 ft by 100 ft. The roads would easily accommodate the motor car. The towns have hollow centres and the road system is more like a simple grid wrapped round upon itself than a radial and circumferential system. The minimum road width is 60 ft whilst the six principal boulevards are 120 ft as are the two principal avenues. The nation would then be living in towns, which could accommodate the motor car yet be small enough to permit easy pedestrian access to many different functions. Everyone would be able to own a house and garden. Yet the really remarkable thing about the proposition is this: 4,000,000 acres of land that is expected to be built on by the year 2000 would not be required. In fact, although the population would be twice the size of that of Howard's day it would have been accommodated on the same land as was urbanised in 1898. Since then the urban land stock has doubled, and it is expected to have trebled by the year 2000. Howard cannot be charged with any waste of land.

A simple question that can be asked is this: if every household in the

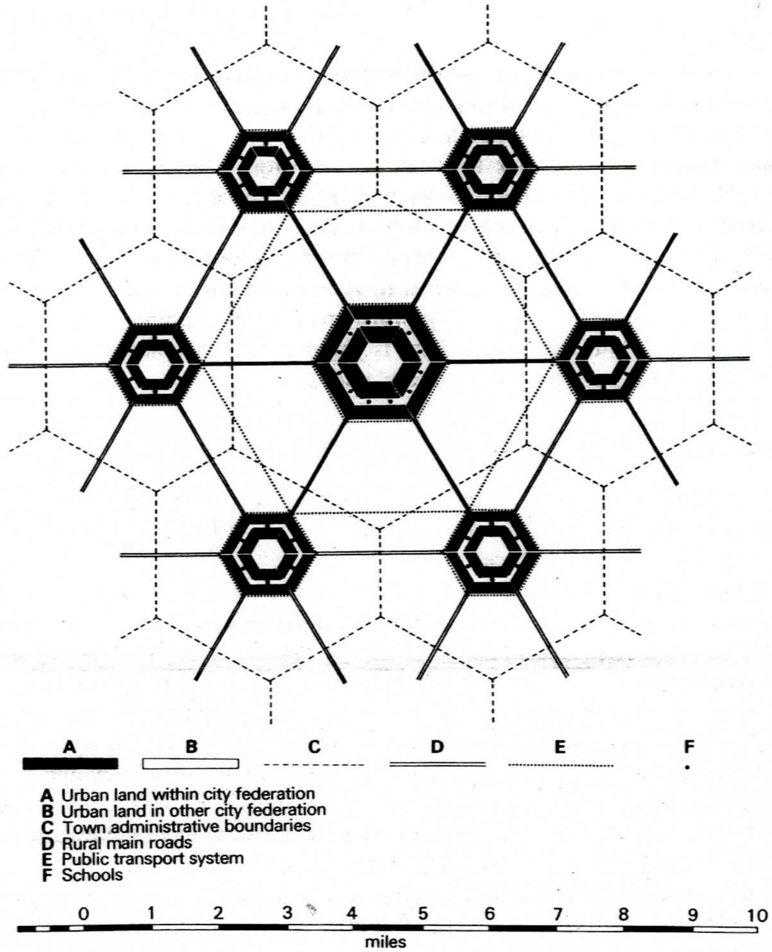


Fig. 2.8. Ebenezer Howard's cluster of garden cities forming a city federation of 250,000 persons.

year 2000 could have a house, a garden and a car on 2,000,000 acres of urban land, why will they not have a house, a garden and a car on three times as much? A more equitable distribution of land would ensure a house and a garden for all who want one. Yet, even if land were not distributed evenly, this simple desire could be answered to some extent by more rational land use planning in relation to the built forms required for the house and garden.

First let us look at how 10% of a land area might be covered by urban

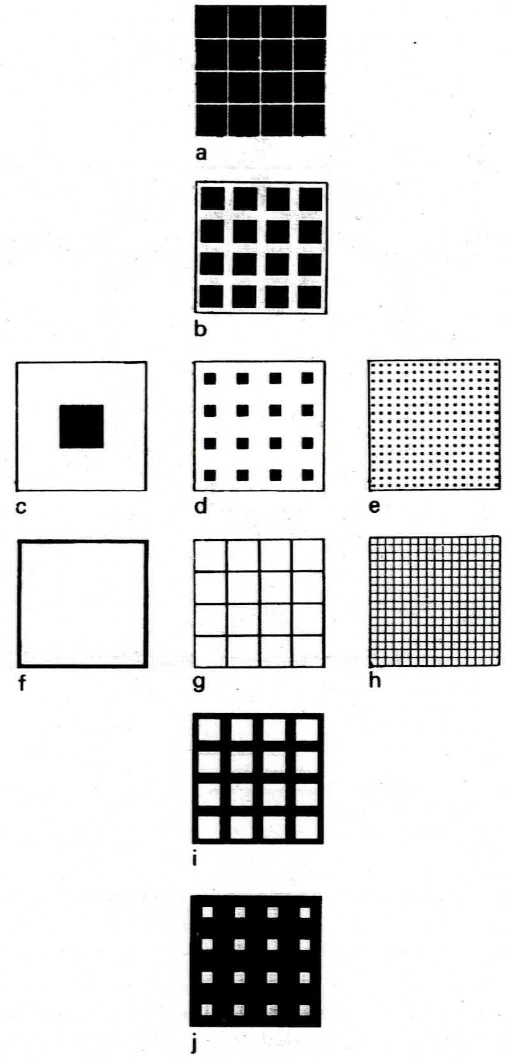


Fig. 2.9. Range of nucleated and linear distributions from 10% to 9% coverage.

uses. This 10% is the present proportion of urban land to all land in England and Wales and it includes urban open spaces like parks, but not agricultural land within urban administrative boundaries. Fig. 2.9c shows the 10% coverage distributed in a concentrated nuclear form (one single blob) and Fig. 2.9e in a dispersed nuclear pattern (in this case 256 blobs).

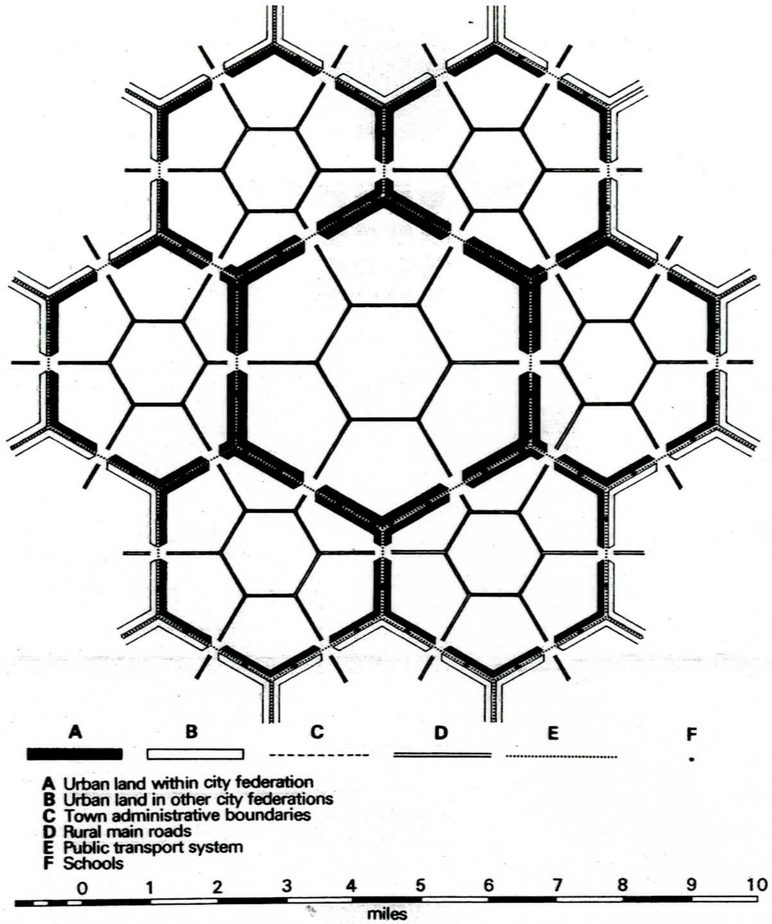


Fig. 2.10. Linear antiform of Howard's city federation.

Figs. 2.9f–h, however, show the same amount of urban land distributed in a linear manner. The pattern illustrated in Fig. 2.9f may be described as concentrated linear (a coarse mesh) and Fig. 2.9h as dispersed linear (a fine mesh). Fig. 2.9a shows 90% coverage, while Figs. 2.9i and 2.9j show the inverted scheme of linear coverage.

There are three properties of the distribution. The topological property of being nuclear or linear corresponds to thinking blobs, *or* thinking of the spaces between. The second property is concerned with scale. The property of being concentrated or dispersed is dependent on the scale chosen to observe the pattern. If, for instance, 1/256 of the dispersed blob pattern (9e) were to be seen at close range, it would look exactly like the concentrated blob pattern (9c). The only difference is one of scale. The third property is the amount of coverage. This can be high (90%) or low (10%). So far no set population has been given. Assume that it is fixed and is independent of land coverage. It will be clear, with a fixed population, that if the land coverage is high (90%) the gross residential density will be relatively low and proportional to 100/90 = 1.1. If, on the other hand, the land coverage is low (10%) the gross residential density will be high and proportional to 100/10 = 10. This low coverage is associated with high density. But the important point is that the notions of concentrated or dispersed developments have no relationship to population density. It is as possible to have a high-density dispersed pattern as a low-density concentrated pattern.

Next, if the pattern is assumed to be continuous and isotropic there are just three geometric arrangements – triangular, rectangular or rhombic, and hexagonal. For the sake of simplicity the rectangular pattern is used here with the sole exception of the next example. This shows (Fig. 2.10) the think-line version of Howard's city federation. Exactly the same proportion of land is urban here as in the think-blob arrangement, and approximately one-quarter of this urban land is open space. It is not solidly built-up.

It can be shown mathematically that the schools are likely to be more accessible in the linear form. The same is true of any other social function that is distributed evenly with the population. But perhaps the most significant difference between the two arrangements is that in the nuclear pattern driving across country requires movement across the town (or alternatively the construction of a special ring road), whilst the linear pattern is interrupted only briefly by urban development and, if the urban parks are placed at these points, cross-country routes need not pass through built-up areas at all.

Speculation 9 (March 1968)

Next consider the correlation of residential building forms and density. The present housing yardstick, for example, implicitly assumes that as densities increase houses decrease in favour of flats, and low buildings give way to high. This is only true because of the professional separation of land use planning from its architectural implications. With favourable land use planning, semi-detached houses can be built at 200 persons to the acre. Three-storey terraces under more normal circumstances can be built up to 265 persons per acre. These are facts. Thus, instead of permitting the highest densities in the countryside where they can make the greatest sense, we insist on putting the highest density towards the centres of our cities.

This tendency may be represented by considering a city marked out from its centre in equal width bands (Fig. 2.11a). Each of these bands accommodates an equal amount of built space. Close to the centre, the built space will have to be achieved in the sky whilst on the perimeter this same quantity of space will be found on the ground. In conventional terms, if the plot ratio is 4:1 in the centre it will be, at the 9th and outermost ring, only 0.055:1, or if a building on the outskirts is one storey high, at the centre 72 storeys will be required. Abandoning the density cone concept, the whole built form could be disposed at an average plot ratio of

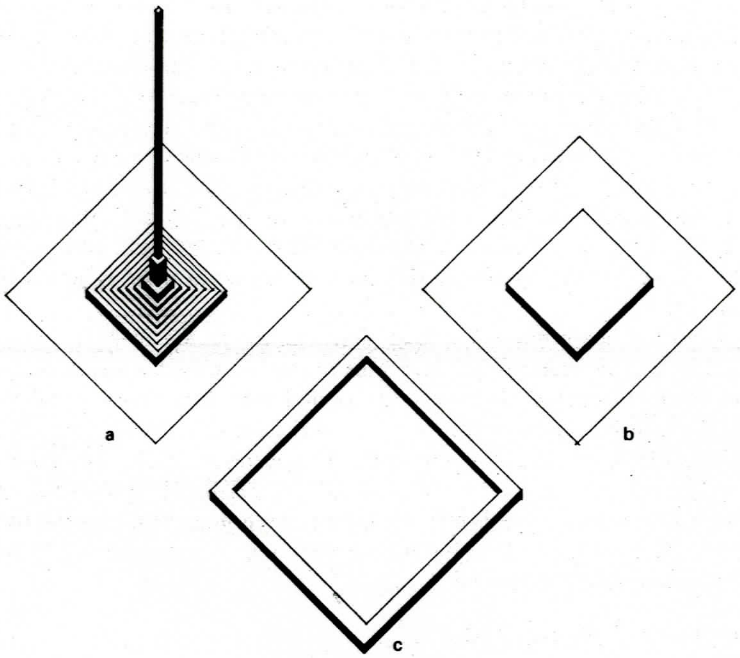


Fig. 2.11. Housing density in relation to its distribution.

0.11:1 (Fig. 2.11b), or just twice that of the 9th ring. This plot ratio of 0.11:1 is only marginally higher than the mean of the four outermost rings, but a great deal lower than the mean of the five inner rings. Fig. 2.11c shows the same built space distributed in a linear form. Closeness and accessibility of similar functions are likely to be improved in a linear route development and since skyscrapers do not use central land very efficiently, the only sense that high buildings make in nucleated centres is in terms of

real estate speculation. In terms of accommodating built space on urban land they are extravagant and irrational gestures. To return to housing densities, there is not much point in thinking of densities as great as 200 persons per acre (when the mean density is likely to be not more than 25 persons per acre in the year 2000), if it were not that by taking extreme situations it is often possible to see principles more clearly.

Speculation 10 (March 1967)

In the study of Hook New Town, 16 acres of open space (including recreational areas) were allowed for every 1000 persons. At this rate 1280 persons would require about 20 acres, or a space 900 ft square (Fig. 2.12a). These persons could be housed in a ribbon of 3-storey housing with a small garden at 200 persons to the acre around their own public open space. The spatial effect would be like Parker's Piece in Cambridge. The access road would be like any simple terrace development. When one considers just how complex housing at this kind of density has become, it is timely to ask whether more might be achieved by a return to relaxed simplicity. A further modification is shown in Fig. 2.12b where all the houses might have a view of the countryside.

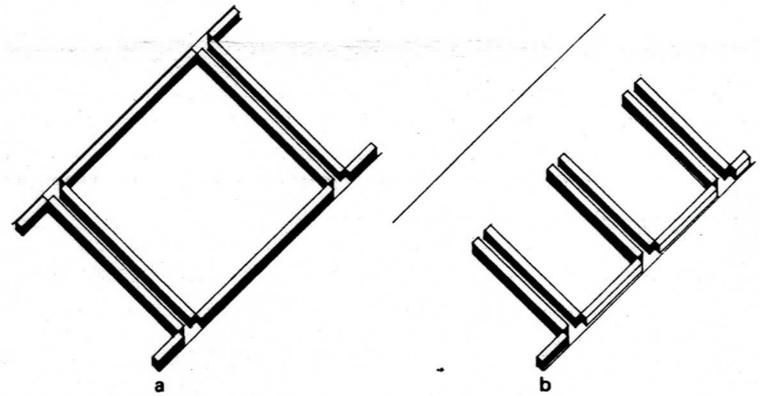


Fig. 2.12. Simple high density housing forms.

In all this the rural districts have a tremendous part to play. Already they are developing more rapidly than the urban areas, excepting the new towns. It is there that the new city is emerging. What pattern will it take? There are many excellent geometrical reasons, especially of a probabilistic nature, to suppose that a free, loose development along a network of routes has advantages of capacity, accessibility, density and use distribu-

tion not possible in nuclear development and that, with a positive policy towards open spaces, it is likely to prove the most reasonable form for the emergent city.

But planners will never know until the capacity has been developed to understand and measure the forces that are at work and to compare alternatives.

Speculation 11 (Martin 1968)

In order to find the full implications in the measurement and invention of built forms it will be necessary to use the techniques that have been developed in other disciplines and which are capable of describing highly complicated situations with greater certainty and clarity. Beyond this it is necessary for such techniques to demonstrate the relationships between different factors and the way that they affect each other. And finally it is necessary to be able to assess more accurately the effect of change. By means of such techniques it becomes possible to represent aspects of the world around us in highly complex models within which the relationships of all the measurable elements can be seen.

Econometrics, the 'mathematical movement' in economics, is only one of a number of developments in many spheres of thought in which an effort is being made to find a structuring theory of organization around which growth and change can develop, and to make this precise by mathematical expression. It has happened within the last half century and mainly since the war. The change has been profound. The description of this change by Stone (1966) with its emerging possibility of integration between studies which are now specialised and separate, has its parallel in urban geography (Robson 1969) and its various extensions.

The use of a mathematical formulation in the attempt to describe the ordering structure that lies behind a building or a city can be seen as another aspect of that texture of relationships through which we try to understand the complexity of an urban area. In developing such a study, the specialised division between architecture and planning has no particular significance and the developing language would take a form which others, notably the geographers and economists, are already using.